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LARGE AREA CROP INVENTORY EXPERIMENT (LACIE)



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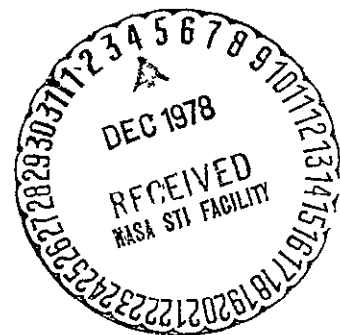
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LACIE PHASE II ACCURACY ASSESSMENT PLAN



National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

NOVEMBER 1976

LARGE AREA CROP INVENTORY EXPERIMENT (LACIE)
PHASE II ACCURACY ASSESSMENT PLAN

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ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS:

AA	Accuracy Assessment.
AA-01	LACIE Phase II AA Report for February 1976.
ACC	adjustable crop calendar.
Agromet	agricultural/meteorological.
AI	analyst-interpreter.
Biowindow	biological window — a Landsat data acquisition period that is related to the biostages of wheat development. The LACIE approach is based on the judgment that wheat can be separated adequately from other crops by analysis of up to four acquisitions of Landsat data during the growing season. The biowindow may be updated if there is a significant lag or advancement in the current crop calendar. The sequence chosen includes acquisitions during the following biowindows: 1. Crop establishment — from 50 percent tillering to 50 percent jointing (biostage 2.3 to 3.0). 2. Green — from 50 percent jointing to 50 percent heading (biostage 3.1 to 4.0). 3. Heading — from 50 percent heading to 50 percent soft dough (biostage 4.1 to 5.0). 4. Mature — from 50 percent soft dough to 50 percent harvest (biostage 5.1 to 6.0).
Biostage or biophase	biological stage, biological phase — the specific stage of development of a crop which can be recognized by a major change in plant structure; i.e., emergence after germination, jointing, heading, soft dough, ripening, and harvest, which are represented by integers on the Robertson Biometeorological Time Scale.
Blind site	a LACIE sample segment chosen at random after normal analysis; used for testing classification performance.

BMTS	Biometeorological Time Scale.
CAMS	Classification and Mensuration Subsystem.
CAS	Crop Assessment Subsystem.
CCEA	Center for Climatological and Environmental Assessment -- an organization of the National Oceanic and Atmospheric Administration, Columbia, Missouri.
Classification	in computer-aided analysis of remotely sensed data, the process of assigning data points to specified classes by a testing process in which the spectral properties of each unknown data point are compared with spectral properties typical of the subject being classified.
Classification error	a measure of the degree to which the LACIE CAMS overestimates or underestimates the wheat acreage in one or more LACIE samples.
CMR	CAS Monthly Report.
COM	classification on microfilm.
CRD	Crop Reporting District -- a geographical area used by the U.S. Department of Agriculture for the collection and reporting of agricultural information; each district consists of several counties.
Crop calendar	a calendar depicting the biostages of the major crop types within a specified region during a calendar year.
Crop calendar adjustment	an adjustment made to the normal crop calendar on the basis of current meteorological data.
CUR	CAS Unscheduled Report.
CV	coefficient of variation (estimate of the standard deviation divided by the estimate of the mean).
DAPTS	Data Acquisition, Preprocessing, and Transmission Subsystem.
Group 2 segment	LACIE segment in a county that historically produces small quantities of wheat/small grains; samples are allocated with probability proportional to size.

Group 3 segment	LACIE segment in a county that historically produces very small quantities of wheat/small grains; estimates are based on the changes in acreage of group 1 and 2 segments from year to year.
IE	Information Evaluation.
IMR	IE Monthly Report.
ITS	intensive test site -- a LACIE segment in the United States or Canada on which detailed crop information is collected by using ground and airborne equipment.
JSC	Lyndon B. Johnson Space Center of NASA, Houston, Texas.
LACIE	Large Area Crop Inventory Experiment.
Landsat	Land Satellite -- formerly called ERTS (Earth Resources Technology Satellite); operates in a circular, Sun-synchronous, near-polar orbit of the Earth at an altitude of approximately 915 kilometers; orbits the Earth about 14 times a day and views the same scene approximately every 18 days.
LEC	Lockheed Electronics Company, Inc.
LPDL	LACIE Physical Data Library.
LPP	LACIE Performance Predictor.
MSS	Multispectral Scanner System or multispectral scanner -- the remote sensing instrument on Landsat that measures reflected sunlight in various spectral bands or wavelengths.
Multitemporal analysis	analysis of data sets over the same area acquired at different times during the growing season.
NASA	National Aeronautics and Space Administration.
NOAA	National Oceanic and Atmospheric Administration.
90-90 criterion	criterion that the LACIE U.S. Great Plains production estimate be 90 percent accurate, at harvest, 90 percent of the time (in comparison with the true value).

PCC	probability of correct classification.
PFC	production film converter.
PPS	probability proportional to size.
RTEB	Research, Test, and Evaluation Branch.
Sample segment	a 5- by 6-nautical-mile area selected by stratified random sampling; information is recorded by the MSS and transformed into computer-compatible tapes and film products.
Sampling error	a measure of the degree to which the estimated wheat acreage in the LACIE sample segments does not represent the wheat acreage contained in the stratum being sampled.
USDA	U.S. Department of Agriculture.
USDA/ASCS	USDA Agricultural Stabilization and Conservation Service.
USDA/FAS	USDA Foreign Agricultural Service.
USDA/SRS	USDA Statistical Reporting Service.
U.S. Great Plains	an area encompassing the nine states of Colorado, Kansas, Minnesota, Montana, Nebraska, North and South Dakota, Oklahoma, and Texas; it is divided geographically into (1) the U.S. southern Great Plains, which includes Colorado, Kansas, Nebraska, Oklahoma, and Texas, and (2) the U.S. northern Great Plains, which includes Minnesota, Montana, and North and South Dakota.
WMO	World Meteorological Organization.
YES	Yield Estimation Subsystem.

SYMBOLS:

$\hat{P}$	wheat/small-grain proportion estimate.
P_W	proportion of wheat harvested.
σ	standard deviation.
$CV(\hat{W})$	CV for production estimate.

P_{GT}

Proportion of wheat/small grains based on identification of each field in the blind site or ITS by USDA/ASCS personnel.

1. INTRODUCTION

The Large Area Crop Inventory Experiment (LACIE) is an inter-agency endeavor of the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Agriculture (USDA). Its purposes are to demonstrate the economical importance of utilizing satellite remotely sensed data from the Land Satellite (Landsat) for agricultural applications; to test the capability of a system utilizing remote sensing in conjunction with climatological, meteorological, and conventional data to produce timely estimates of the production of a major world crop prior to harvest; and to validate the technology and procedures for such a system.

In accordance with the objectives of the LACIE, the Accuracy Assessment (AA) effort is designed to check the accuracy of the products from the experimental operations throughout the growing season and thereby determine if the procedures used are sufficient to accomplish the above objectives. The LACIE AA Team (appendix A) is responsible for the technical direction of the AA program.

The purpose of this LACIE Phase II AA Plan is to provide the specific guidelines for evaluating the accuracy of the Phase II procedures and estimates of wheat/small-grain acreage, yield, and production and thereby determine if the LACIE is satisfying the requirement that its production estimates be 90 percent accurate, at harvest, 90 percent of the time when compared with the true value of harvested wheat/small grains (the 90-90 criterion).

This document was prepared by Lockheed Electronics Company, Inc. (LEC), Aerospace Systems Division, Houston, Texas, under contract

NAS 9-12200 for the Earth Observations Division, Science and Applications Directorate, Lyndon B. Johnson Space Center (JSC) of NASA.

2. BACKGROUND

In accomplishing its objectives, the LACIE uses Earth Resources Program technology in conjunction with meteorological and conventional agricultural information to examine three global crop seasons, each of which is designated as a LACIE phase.

Phase I, which began in January 1975, was devoted primarily to identifying and estimating wheat acreage in the states of Colorado, Kansas, Minnesota, Montana, Nebraska, North and South Dakota, Oklahoma, and Texas (the U.S. Great Plains). Recognition analyses were conducted in other selected areas, and yield model development and yield feasibility determinations were made over selected regions in the United States. Data from the USDA Statistical Reporting Service (USDA/SRS) were compared with LACIE estimates to determine the accuracy of LACIE performance.

Phase I AA activities were initiated in July 1975, and tests for wheat acreage accuracy were conducted using segments for which ground-truth data were available. Initially statistical tests and comparisons of LACIE estimates with ground truth were made using data from 27 intensive test sites (ITS's) in eight states and 2 Canadian ITS's; then, to test a greater number of acquisitions in a more concentrated area, ground truth was gathered from 30 LACIE operational segments (blind sites) in two states and withheld from the analyst-interpreters (AI's) until processing was completed. The Classification and Mensuration Subsystem (CAMS) processed the data from the blind sites, and the AA Team compared the results of the various sampling and classification procedures used. Approximately 340 special analyses were conducted to support Phase I AA.

In Phase II, which begins in October 1975, emphasis remains on the U.S. Great Plains but analysis will be extended also to include ITS's in Canada.

3. OBJECTIVES AND SCOPE

3.1 OBJECTIVES

The requirements for AA are established to evaluate and improve LACIE procedures and thereby to support the primary objectives of the LACIE as stated in section 1. Phase II AA will continue to test and evaluate LACIE estimates of wheat acreage as in Phase I and has been expanded to include evaluation of yield and production estimates as well. Specifically, the objectives of the Phase II AA program are:

- a. To establish experimental designs and conduct analyses which allow
 - Computation of the variance, bias, and confidence limits for LACIE estimates of acreage, yield, and production.
 - Identification of LACIE errors to a level of detail sufficient to determine the source and magnitude of component error contributions and, if possible, to recommend solutions for correction of the related problems.
 - Investigation of problems identified in the Information Evaluation (IE) Monthly Report (IMR).
- b. To define the requirements for gathering ground truth, satellite imagery, aircraft photography, and other ancillary data necessary to support the accuracy and reliability assessment of LACIE estimates of acreage, yield, and production. This task involves monitoring the LACIE acquisition process to ensure the timely application of program resources in the AA data-gathering process.
- c. To report on the experimental findings (in format reports and in informal briefings to project personnel) in a manner that will support the preparation of LACIE project evaluation reports.

3.2 SCOPE

The Phase II-AA program is designed to assess and evaluate, in a quasi-operational mode, the capabilities of LACIE to develop wheat acreage, yield, and production estimates for the United States that will meet the 90-90 criterion in the U.S. Great Plains. The AA process requires the multiagency collection and subsequent evaluation by the LACIE of the following data:

- a. LACIE imagery and classification data.
- b. Aerial photography (the basis for development of field maps).
- c. Field maps and land-use annotations developed from USDA Agricultural Stabilization and Conservation Service (USDA/ASCS) ground observations.
- d. Inventories of all fields after fall planting for winter wheat areas and after spring planting for both spring and winter wheat areas.
- e. Periodic observations of ITS's within 3 days of each Landsat overpass (every 18 days).

These data will be collected

- From 40 blind sites in the U.S. southern Great Plains for early-season and at-harvest evaluations.
- From 136 blind sites throughout the U.S. Great Plains for at-harvest evaluations.
- From 27 ITS's throughout the U.S. Great Plains for evaluations throughout the growing season.

Listings of ITS's and blind sites are presented in appendix B.

The AA Team will monitor the processing of the above data set for the United States and compare:

- a. LACIE estimates of acreage, yield, and production with those obtained from ground observations by the USDA/ASCS over the above sites.
- b. LACIE estimates of acreage, yield, and production at the Crop Reporting District (CRD), state, regional, and national levels with similar USDA/SRS estimates.
- c. LACIE adjustable crop calendar (ACC) estimates with USDA/SRS wheat-growth-stage information from the ITS's.

In addition, AA personnel will assemble and evaluate similar data from 10 Canadian ITS's and compare LACIE estimates in Canada with USDA Foreign Agricultural Service (USDA/FAS) reports at the national level.

4. GENERAL TECHNICAL APPROACH

Three groups of activities are required to implement the LACIE Phase II AA and satisfy its objectives:

- a. Data requirements definition and acquisition monitoring
- b. Data analysis and evaluation
- c. Reporting

A detailed flow diagram of the Phase II AA program and related LACIE operational activities is presented in figure 4-1. Specific descriptions of the AA tasks associated with each group of activities are presented in section 6.

4.1 DATA REQUIREMENTS DEFINITIONS AND ACQUISITION MONITORING

The first group of the Phase II AA activities involves the identification of data requirements to support the accuracy evaluations of the various LACIE component products and the monitoring of data acquisitions by the LACIE operational organization and related NOAA and USDA functions. These activities involve the identification of LACIE operational data products to be used in AA, the definition of methods by which these products can be retrieved in a timely manner from LACIE operations for AA analyses, and identification of requirements for reference and control data from NOAA and USDA.

AA Team members will (1) select blind-site data at random (approximately 40 sites for early- and late-season evaluations and approximately 136 sites for late-season evaluations) from segments which have at least one Landsat acquisition and which have been processed by the CAMS and forwarded to the Crop Assessment Subsystem (CAS) and (2) coordinate action for acquiring ground truth from the blind sites and ITS's in the United States and for retrieving CAMS classification data for these sites from LACIE operations. The locations of the blind sites are withheld

from the CAMS AI's so that these segments will be processed as regular operational segments.

Although AA data acquisition is largely accomplished by LACIE operations personnel, extensive coordination will be required by AA in order to ensure the timely and accurate selection of blind sites and the gathering of adequate evaluation data.

The specific tasks to implement the above activity are identified as tasks 1 through 8 in figure 4-1. Specific descriptions of these tasks are provided in section 6.1.

4.2 DATA ANALYSIS AND EVALUATION

The second group of activities of Phase II AA concerns the analysis and evaluation of the basic data collected during the initial AA activities. Comparative statistics are developed to support evaluations of LACIE acreage, yield, and production estimates. This will require the processing of subsets of these data, which are appropriate for the specific AA evaluation being conducted. Appropriate statistics are calculated to satisfy the experimental queries in the evaluations.

Phase II AA evaluations are designed to examine the LACIE operational products (estimates of acreage, yield, and production) and related errors over the U.S. Great Plains. This includes the winter-wheat states (the U.S. southern Great Plains; i.e., Colorado, Kansas, Nebraska, Oklahoma, and Texas) and the spring-wheat states (the U.S. northern Great Plains; i.e., Minnesota, Montana, and North and South Dakota).

In order to accomplish its objectives of determining the magnitude and components of error in LACIE estimates and of ascertaining

whether or not the LACIE is satisfying the 90-90 criterion, AA will:

- a. Determine the error in LACIE estimates of acreage, yield, and production.
- b. Establish an error budget and compute the coefficients of variation (CV's) of LACIE production estimates and compare them to the budgeted values to determine if the 90-90 criterion is being met.
- c. Through detailed investigation, examine the potential sources of error within the LACIE estimates. This includes evaluating acreage estimation error sources within classification, sampling, and aggregation activities. Yield and production error sources will also be evaluated. If possible, these studies should provide recommendations of ways and methods to reduce the error.
- d. Investigate the various error types and the magnitude of their effects on LACIE performance through development and usage of a LACIE Performance Predictor (LPP) model in evaluative simulations of the LACIE operational system.

The specific methods for implementing these tasks are identified as tasks 10 through 35 in figure 4-1. Specific descriptions of these tasks are provided in section 6.2.

4.3 REPORTING

Reporting for Phase II AA will consist of the following three reporting methods:

1. Special AA management briefings and presentations
2. AA monthly quick-look reports
3. Phase II AA Report

AA will provide LACIE management with special briefings and presentations on the status of AA data acquisitions and special problems during the 1975-76 winter- and spring-wheat growing seasons. These briefings provide timely responses to management requests for visibility into LACIE processes throughout the growing season and support to LACIE management in providing information on current LACIE status and problems to upper-level NASA, USDA, and NOAA management.

AA will also provide monthly quick-look reports to LACIE management consisting of comments on current CAS Monthly Reports (CMR's) throughout LACIE Phase II. The comments will be the result of AA cursory reviews of these reports. The monthly quick-look reports will provide technical comments on the data presented and report on special problems and the results of any investigations of these problem areas conducted by AA. Some of these problems may be the subject matter of planned Phase II AA investigations of LACIE error sources. If the nature of the problems identified in the CMR and IMR reviews warrants special studies, they will be initiated as part of the Phase II AA investigations.

In addition to the monthly quick-look reports, AA will prepare a Phase II AA report developed through a series of interim reports that are prepared throughout Phase II. The first interim report consists of evaluations of early-season winter-wheat estimates in the U.S. southern Great Plains. The second interim report examines early- and late-season winter-wheat estimates in the same area. The third interim report provides AA evaluations of at-harvest estimates of U.S. winter and spring wheat over the U.S. Great Plains. A fourth interim report will be developed to serve as a draft of the final Phase II report. It will be reviewed and revised to become the final Phase II AA report.

This iterative building-block process of preparing the Phase II AA report has been developed to allow a thorough review and critique of each report, with the technical comments being used to upgrade and improve the succeeding drafts of the report. It also provides for the analysis and addition of technical data that become available during the interim period between report drafts.

A detailed description of the basic reporting formats and the suggested content of these reports are provided in the detailed task descriptions presented in section 6.3 of this plan.

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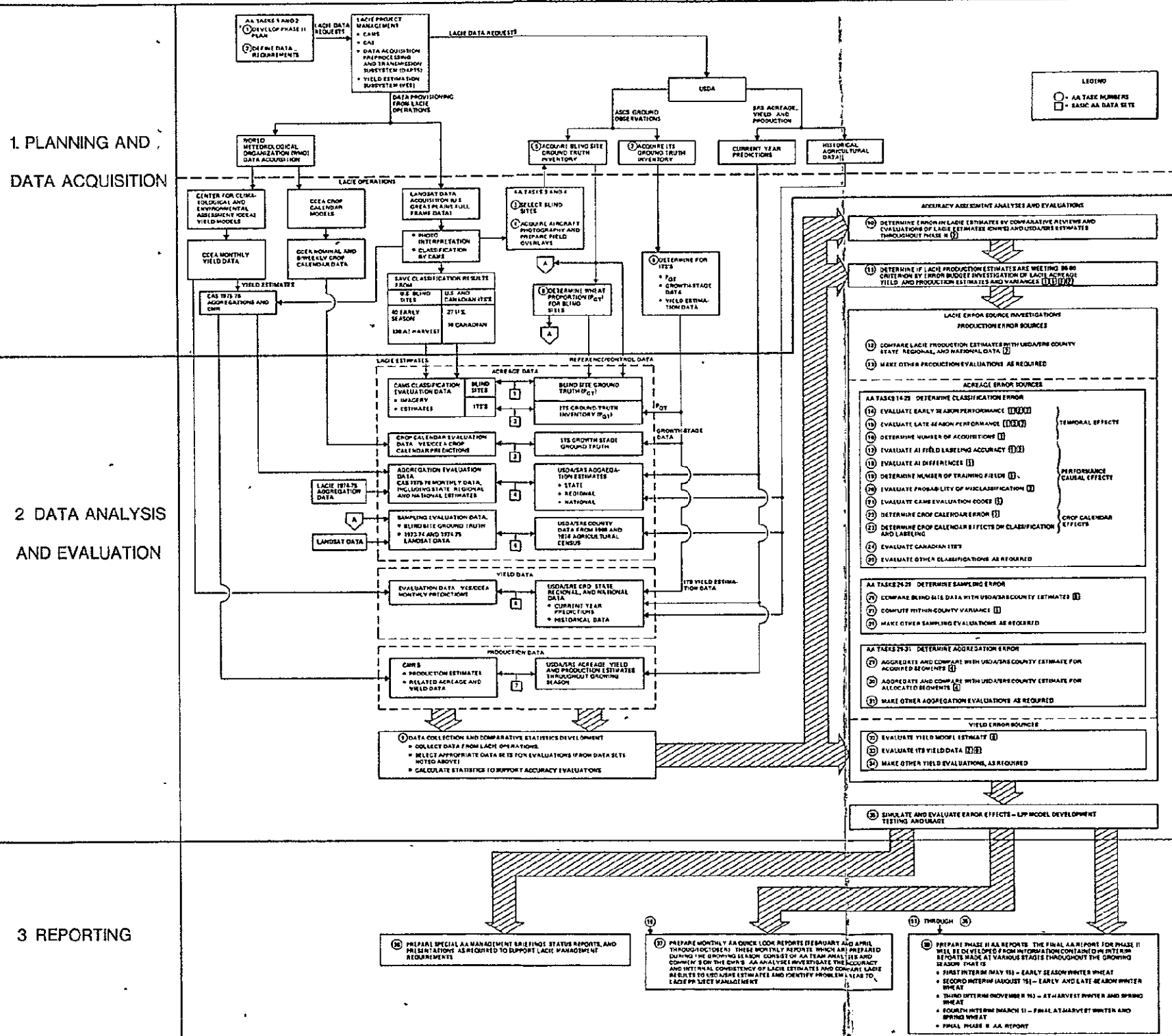


Figure 4-1.— Schematic diagram of LACIE Phase II Accuracy Assessment.

5. SCHEDULE AND RESOURCE REQUIREMENTS

The schedule and resource requirements for implementing LACIE Phase II AA are presented in the following sections.

5.1 SCHEDULE

The Phase II AA schedule is presented in figure 5-1.

5.2 RESOURCE REQUIREMENTS

The resource requirements for LACIE Phase II AA are summarized in table 5-1, which summarizes the manpower and computer requirements associated with specific AA tasks or task groups.

TABLE 5-1.- RESOURCE REQUIREMENTS FOR LACIE PHASE II ACCURACY ASSESSMENT

Task number	Task or task group title	Manpower requirements (man-year equivalents)								Computer requirements			
		Management	Agronomy/ climatology	Computer programming	Clerical assistants	CAMS analysis	Statistical analysis	Accuracy team	Cartography	UNIVAC 1108 Exec II (hrs)	UNIVAC 1110, Exec VIII (hrs)	ERIPS ^a (hrs)	IMAGE 100 ^b (hrs)
1-8	AA planning and data-gathering tasks	2.9			1.0	1.0		1.2	1.5				
9-35	AA data analysis and evaluation tasks	1.7	1.5	2.0	.2	7.0	4.5	.6		75	15	500 (normal operations 344)	40
36-38	AA reporting	.4	.3		1.0		1.5	.2					
	Total Phase II requirements	5.0	1.8	2.0	2.2	8.0	6.0	2.0	1.5	75	15	500 (normal operations 344)	40

^aEarth Resources Interactive Processing System.

^bInteractive Multispectral Image Analysis System, model 100.

PHASE II ACCURACY ASSESSMENT SCHEDULE

STATUS AS OF 2/13/76

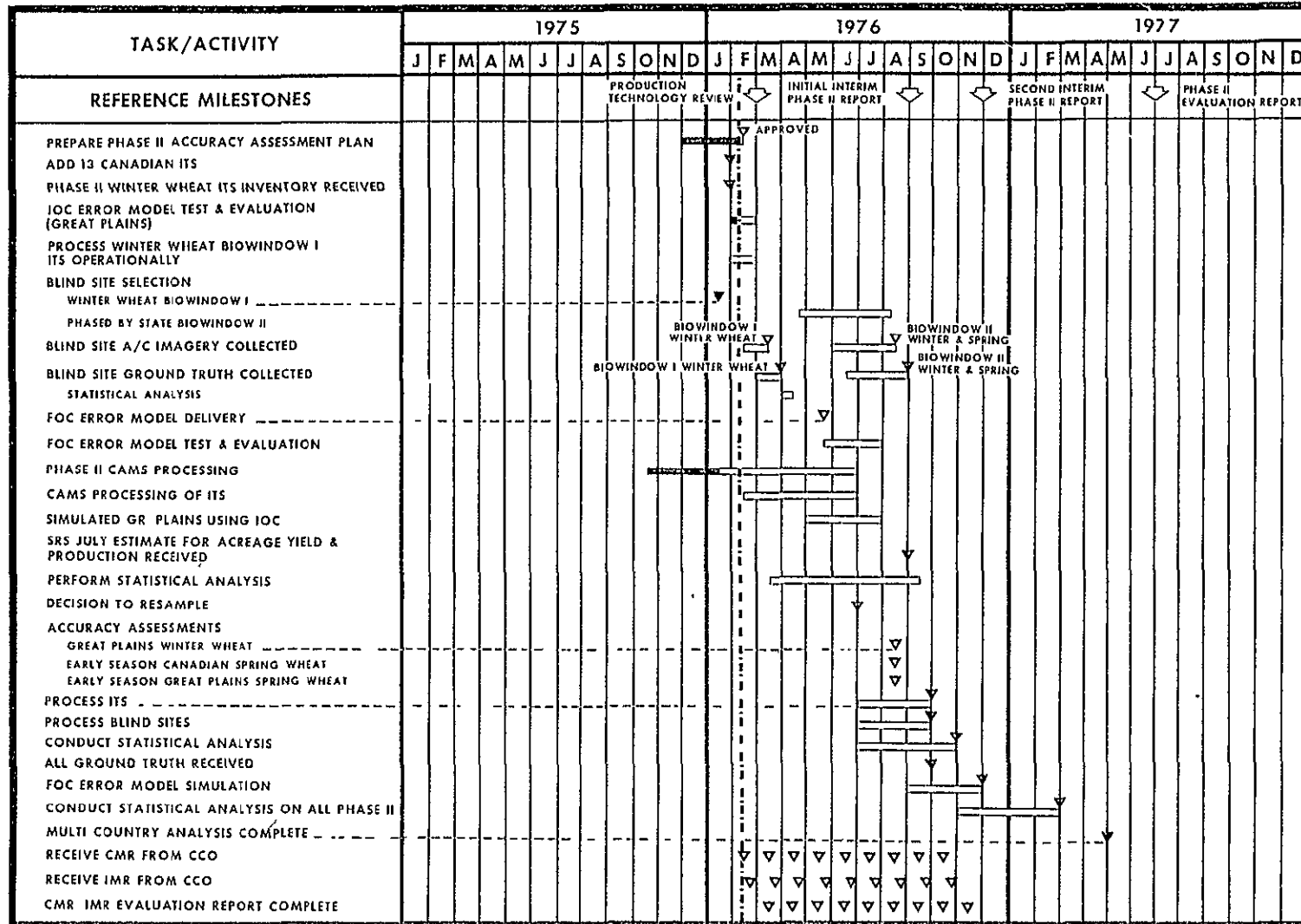


Figure 5-1.- Phase II Accuracy Assessment Schedule.

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6. TASK DESCRIPTIONS

Detailed descriptions of the tasks that comprise AA for Phase III are included in the following subsections.

6.1 PLANNING AND DATA ACQUISITION

One of the three major elements of Phase III AA is the planning and coordination of analytical and data acquisition activities of the program. This involves (1) the determination of the basic data requirements that will satisfy the analytical and evaluational requirements of the program, (2) the coordination of data acquisition resources so that the timely acquisition of data is accomplished, and (3) the monitoring of data quality to assure that the data acquired are of satisfactory technical quality for assessing the accuracy of the LACIE estimates of acreage, yield, and production.

The AA program depends on the LACIE functional elements (CAMS, CAS, YES, and DAPTS) to provide a majority of the data necessary for evaluations. Specific task descriptions are not included in the AA plan for this LACIE operations data development and provisioning effort. Only the AA data acquisition tasks where direct involvement of the AA Team or support personnel is required are identified and described in the following paragraphs.

6.1.1 PLAN DEVELOPMENT

The initial activities of Phase II AA are directed to the development of an AA plan. This involves definition of the program scope, data/resource requirements, scheduling, and task descriptions of the activities planned for Phase II. The planned activities of the Phase II AA program are documented in this Phase II AA plan.

6.1.2 DATA REQUIREMENTS

Required inputs from the LACIE functional elements have been identified through the planning for AA investigations. The basic inputs are defined in the following subsections. As special problems are identified, these requirements may be expanded to satisfy newly defined AA needs.

6.1.2.1 Classification and Mensuration Subsystem

The following data and information are required from the CAMS records for all 1975-76 U.S. blind sites and ITS's (see appendix A).

- a. A copy of the CAMS evaluation form for every acquisition and every run
- b. A standard classification summary and statistical report for every run
- c. The printed output of the classification-on-microfilm (COM) tape for each batch run
- d. Printer outputs for each run when the CAMS-CAS interface tape becomes operable
- e. A classification map
- f. Training- and test-field coordinates for every run
- g. A record of the AI interpretation of the biostage

All of these items shall be collected by segment number and LACIE crop year and stored so that all items from each run can be easily collected by AA for use in performing the analyses defined in section 6.2 of this plan.

In addition to the above, full-frame Landsat multispectral scanner (MSS) color infrared imagery is required from several counties in each U.S. Great Plains state for photointerpretation of every segment in each county selected. These counties will

be defined in the LACIE sampling plan document and utilized by the Sampling Team to provide AA with evaluations of within-county variance.

6.1.2.2 Crop Assessment Subsystem

The following data and information inputs are required from CAS during Phase II AA:

- a. CMR's, which include LACIE Phase II estimates of acreage, yield, and production as they are developed throughout the growing season.
- b. The standard statistics for LACIE Phase II estimates of wheat acreage, yield, and production, which include the standard deviation (σ), the CV, the 90-percent confidence limits, and the probability of a 10-percent relative error.

6.1.2.3 Yield Estimation Subsystem

The following data and information inputs are required from the YES during the Phase II AA:

- a. ACC data over the 27 ITS's in the U.S. Great Plains are required periodically (after completion of each growth stage) throughout the winter- and spring-wheat growing seasons, and USDA/ASCS estimates are required for the same periods in the following CRD's:
 - Texas (1N, 1S, 2N, 2S, 5N, 5S, 8N, and 8S)
 - Kansas (all CRD's)
 - North Dakota (all CRD's)
 - Montana (1, 2, and 3)
- b. Meteorological data, yield estimates, and standard statistics are required for each stratum for specific months as indicated in the schedule which is table 6-1.

6.1.2.4 Data Acquisition, Preprocessing, and Transmission Subsystem

The following data and information inputs are required from the DAPTS during Phase II AA.

- a. The following ground-observation data for all U.S. blind sites:
 - Aircraft photography (the basis for development of field overlays that are used in documenting inventories and interpreting signatures; see section 6.1.4 for specific requirements).
 - Completed spring early-season inventories of the blind sites conducted by USDA/ASCS personnel using the instructions and data recording forms presented in appendix D.
 - Completed at-harvest inventories of the ITS's conducted by USDA/ASCS personnel utilizing the data forms presented in appendix E.
- b. The following ground-observation data (to be collected as a part of LACIE operations) for all U.S. ITS's:
 - Aircraft photography (the basis for development of field overlays that are used in documenting inventories).
 - Completed fall and spring early-season winter-wheat inventories of the ITS's conducted by USDA/ASCS personnel utilizing the data forms presented in appendix E.
 - Completed 18-day periodic observations of the ITS's throughout the wheat growing season until harvest, to be taken within 3 days of Landsat overflights. (The USDA/ASCS will make and record these observations on the forms presented in appendix E.)

- Completed postharvest yield inventory of the ITS's conducted by USDA/ASCS personnel utilizing the data forms presented in appendix E.
- c. Copies of mean historical crop calendars based on the last 15 years, if available, for each acreage stratum for the U.S. Great Plains states and Canada.
- d. Agriculture reports:
 - USDA/SRS reports containing current information on wheat acreage, yield, and production for the United States, including aggregation data at the state, regional, and national levels and yield data at the CRD, state, regional, and national levels. These data are needed on the day the reports are released in order to support the quick-look report.
 - USDA/FAS reports containing current year information on wheat acreage, yield, and production.
- e. Historical agricultural statistics
 - USDA/SRS data on wheat acreage, yield, and production in the United States for 1970-75.
 - USDA Agricultural Census data for 1969 and 1974.
- f. Other required data sets, as specified by AA to satisfy special investigations that may be requested by LACIE project management. AA will specify any such requirements to DAPTS as soon as possible after data requirements are identified.

6.1.3 BLIND-SITE SELECTION

A random sample of blind sites will be selected by the AA Team from LACIE U.S. segments which have at least one Landsat acquisition processed by CAMS and forwarded to CAS.

6.1.3.1 Early Season

The early-season blind sites are selected after release of the CMR for February 1976. Appendix B (table B-3) indicates the states in the U.S. southern Great Plains from which the early-season blind-site selection is made and the expected number of blind-site samples from each of these states.

6.1.3.2 At Harvest

Blind sites for the at-harvest evaluation will be randomly selected for each state from sites having at least one Landsat acquisition processed by CAMS and forwarded to CAS. Appendix B (table B-4) contains a description of the expected number of at-harvest blind sites for each state and additional information about the at-harvest sites. The 40 sites used for the early-season evaluation will also be used for the at-harvest evaluation.

6.1.4 PREPARATION OF BLIND-SITE FIELD OVERLAYS

In order to obtain valid, useful, and documented ground-truth information for use in the Phase II AA evaluations, field overlays must be prepared from aircraft photographs of the blind sites. These field overlays are then used to record the land-use information that supports the acreage determination aspect of the ground-observation inventories conducted throughout LACIE Phase II. The following items are required to prepare the blind-site field overlays.

6.1.4.1 Aircraft Maps

After selection of the blind sites, Landsat imagery is used to determine the true position of each site. AI's determine these positions using production film converter (PFC) products, record the latitude and longitude to the nearest 0.1 minute, and plot

the position of the segment on a 1:24 000- or 1:12 500-scale map. These maps are then used by aircrews in acquiring the aerial imagery.

6.1.4.2 Aircraft Photography

Photography will be collected using RC-8 infrared film from aircraft at an altitude of 6000 to 7200 meters (20 000 to 24 000 feet). Two flight lines will be flown for each site with a 20-percent sidelap. Four frames will be collected for each flight line with a 30-percent forward overlap. All imagery must be collected no later than 4 weeks prior to ground-truth collection. Predesignated flight lines will be established by the LACIE for each blind site.

After aerial imagery is acquired for the blind sites, each frame will be checked to verify that the site was covered and that the imagery is of sufficient quality to be used by the USDA/ASCS personnel in collecting ground truth.

6.1.4.3 Field Overlays and Field Segment Kits

If the imagery is of satisfactory quality to be used by USDA/ASCS personnel, transparent overlays are prepared outlining and identifying fields. The overlays are then placed in field segment kits that are forwarded to USDA/ASCS personnel for use in acquiring ground truth. These kits include:

- A color infrared 2X print of the segment with field overlay
- A topographical map of scale 1:250 000 showing the sample segment location and boundaries
- Crop identification key (standard annotation to be used in documenting land use)
- Survey manual -- a brief definition of field procedures developed at JSC providing guidelines to USDA/ASCS personnel

as to the basic project requirements for recording ground observations of the LACIE blind sites (appendix D)

6.1.5 BLIND-SITE FIELD DATA ACQUISITION

USDA/ASCS personnel provide ground observations, annotations of field overlays, and complete inventory data. Fields are annotated according to the standard crop symbols identified in the crop keys provided in the JSC instructions to USDA/ASCS for making LACIE segment inventories (appendix D). The inventory package is completed by USDA/ASCS personnel and forwarded to JSC to be logged and tracked by DAPTS.

6.1.6 DETERMINATION OF THE WHEAT/SMALL-GRAIN PROPORTIONS FOR BLIND SITES

The LACIE cartographic technician plots the Landsat scene product 1 boundary on a 2X photograph. Using the area mode feature of the H. Dell Foster digitizer, the technician measures the segment area in thousandths of a square inch on the photography. Next, the area of each wheat and small-grain field is measured and the sum of the individual wheat/small-grain fields is divided by the total area of the segment. Likewise, all abandoned wheat/small-grain fields are planimetered, and the sum is divided by the total area. The result will be the percentage of both wheat and small grains.

6.1.7 FIELD DATA ACQUISITION IN INTENSIVE TEST SITES

The field data acquisition from 27 U.S. and 10 Canadian ITS's is an integral part of LACIE operations. These sites are located prior to Phase II operations, and their identities and locations are available to all LACIE personnel (see appendix B). Field data acquired from these sites by USDA/ASCS personnel include the following:

- a. Aerial photography (once yearly)

- b. Field maps annotated by USDA/ASCS personnel
- c. Inventories of all fields (appendix E provides examples of data reporting forms):
 - After fall planting and before harvest for winter-wheat areas
 - After spring planting and before harvest for both spring- and winter-wheat areas
- d. Periodic 18-day observations of a subsample (approximately 50 fields) of each ITS coincident with each Landsat overpass (Appendix E gives an example of a form for recording these 18-day periodic observations.)

These data are forwarded to JSC to be processed and logged by DAPTS. DAPTS then furnishes this information to AA for evaluation.

6.1.8 DETERMINATION OF WHEAT/SMALL-GRAIN PROPORTIONS FOR INTENSIVE TEST SITES

As a part of LACIE operations, the wall-to-wall fall and spring inventories are accomplished, and the crop proportions are calculated for the ITS's in the manner described in section 6.1.6 for the blind sites.

6.2 ANALYSIS AND EVALUATION

The LACIE Phase II AA function designs and conducts experimental evaluations of LACIE estimates of acreage, yield, and production. The purposes of these investigations are (1) to determine error in these estimates, (2) to ascertain whether the error is within acceptable limits for meeting the LACIE 90-90 criterion, and (3) to conduct investigations designed to identify possible sources of the error or, in other words, to identify or point to potential causes of the variation in LACIE estimates from the actual or reference (USDA/SRS) data.

The AA analysis and evaluation function, using data systematically gathered over the yardstick region (U.S. Great Plains), is directed toward drawing inferences as to the performance of LACIE technology if operated for a span of several years.

The following analysis and evaluation tasks and activities are those presently planned to accomplish the LACIE Phase II AA purposes noted above. Detailed descriptions of these tasks are presented in the following subsections.

6.2.1 DATA COLLECTION AND DEVELOPMENT OF COMPARATIVE STATISTICS

This task is an integral part of the analytical activities identified in the following subsections. However, it has been specified as a separate task because of the time demands placed on AA analytical personnel to acquire the data from various locations within LACIE operations and the LACIE Physical Data Library (LPDL). Upon acquisition of these data, the AA Team processes and develops statistics to satisfy the requirements of the AA experimental evaluations.

6.2.2 DETERMINATION OF ERROR IN LACIE ESTIMATES

A prime concern of the AA program is to monitor and status the development of LACIE estimates throughout the growing season. This task requires review and evaluation of LACIE acreage, yield, and production estimates. The evaluations are made largely from comparisons with: (1) similar estimates made over the same state or region during similar times in the growing season by the USDA/SRS and (2) ground truth obtained from ground observations of special sites (blind sites and ITS's).

The error in LACIE estimates is described by the calculated relative difference $\left(\frac{\text{LACIE} - \text{USDA/SRS}}{\text{LACIE}} \right)$ obtained in these comparisons.

Also, states or regions where significant differences are noted will be further evaluated to determine probable causes of these errors.

These comparisons are designed to detect, early in the growing season, any divergences between the estimates and reference standards and thus to identify for further investigations potential LACIE problem areas that might be associated with the divergences.

The results of these reviews and evaluations will be reported in the Phase II AA monthly quick-look reports, which are described in section 6.3.2.

6.2.3 DETERMINATION IF LACIE PRODUCTION ESTIMATES MEET THE 90-90 CRITERION

The procedures for determining if the LACIE production estimates for the U.S. Great Plains are meeting the 90-90 criterion are set out in appendix C. These procedures show that, if the production estimate is unbiased and if the CV for production, $CV(\hat{W})$, at the nine-state level is less than 6 percent, the 90-90 criterion will be met. In general, it is first assumed that the production estimate is unbiased. An alternate approach is to assume that the USDA/SRS production estimates are correct and to define the bias to be the difference between the LACIE production estimate and the USDA/SRS estimate. In this case, the tolerable $CV(\hat{W})$ would be lower than 6 percent. This approach will be investigated during Phase II but probably will not be used operationally to determine if the LACIE is meeting the 90-90 criterion.

The method used to estimate the CV for production at the nine-state level is presented in appendix C.

6.2.4 INVESTIGATION OF LACIE ERROR SOURCES

After determining the error in LACIE estimates and whether or not the estimates are meeting LACIE goals, AA will conduct further investigations to isolate and identify the error sources or potential causes of errors in LACIE estimates. LACIE Phase I AA experience has identified a number of potential error sources associated with the acreage, yield, and production estimates. These will be investigated further in Phase II, along with other likely potential error sources that are identified throughout the analyses conducted during Phase II. The specific tasks involved in these error source investigations are described in the following subsections.

6.2.4.1 Production Error Source Evaluations

The error sources within LACIE production estimates are examined by investigating the following specific tasks.

6.2.4.1.1 Comparisons of LACIE and USDA/SRS Estimates

This task involves the analysis of LACIE production estimates through comparisons with USDA/SRS estimates and evaluations at the county, CRD, state, regional, and national levels. Statistical analyses are performed during the growing season using the standard statistics produced by CAS. Graphical analyses at the state, regional, and national levels are conducted throughout the season to determine if consistent and predictable trends in the development of the estimates can be established. Year-to-year comparisons at the state level are also made in areas where consistent growing conditions have existed.

6.2.4.1.2 Other LACIE Production Estimates

In addition to the above assessments of production error sources, AA examines general reasons for the error in LACIE production estimates. These special investigations, as required, will be fully documented along with the specific evaluations of error sources within the acreage and yield estimates, which are described separately in section 6.2.4.2.

6.2.4.2 Acreage Error Source Evaluations

The error sources within LACIE acreage estimates are evaluated with respect to the specific classification and sampling error evaluation tasks described in the following subsections.

6.2.4.2.1 Classification Accuracy

Error sources associated with the LACIE process of classifying the imagery and determining the proportion of the area that is wheat will be examined through a series of investigations of:

- a. Temporal effects (tasks 14 through 16, figure 4-1)
- b. AI procedural effects (tasks 17 through 20, figure 4-1)
- c. Crop calendar effects (tasks 21 and 22, figure 4-1)

The specific investigation tasks to determine classification error sources are described as follows.

6.2.4.2.1.1 EARLY-SEASON PERFORMANCE EFFECTS. This task will be conducted to ascertain error sources within CAMS estimates of wheat proportions associated with the early phases of the winter- and spring-wheat growing seasons.

The basic data set for these investigations is the CAMS operational classification results (as defined in section 6.1.2.1) and

the ground-truth wheat proportion estimates from blind sites and ITS's. The early-season winter-wheat evaluation sites are located in the U.S. southern Great Plains whereas the early-season spring-wheat evaluation sites are located in the U.S. northern Great Plains.

The locations of and descriptive data on the LACIE ITS's and blind sites to be used in these investigations are presented in appendix B. (ITS's in the States of Washington, Idaho, and Indiana are listed also but will not be utilized in these early-season evaluations). To ensure the processing of the blind-site segments as regular operational sites, specific descriptive data such as blind-site locations are maintained as secure data until after completion of the processing of all Phase II segments.

Evaluations are made by comparing LACIE wheat proportion estimates with those obtained from the ground-truth observations. Relative differences and the standard errors of the relative differences are calculated from these comparisons. The mean errors are then determined for each state and for the five-state early-winter-wheat and four-state early-spring-wheat areas. From these data the AA Team estimates the bias, variance, and confidence limits for LACIE estimates.

In addition to the above blind-site and ITS investigations, temporal plots of wheat estimates for the U.S. Great Plains states are developed as part of task 6.2.2 for the early-season evaluations and are continued throughout the growing season. These plots, which are made by state and aggregated for the U.S. Great Plains, compare LACIE and USDA/SRS acreage estimates. An examination of these data will disclose trends in the development of the estimates and error source information.

6.2.4.2.1.2 LATE-SEASON PERFORMANCE EFFECTS. Basically, this task is the same as the early-season performance effects task,

described in section 6.2.4.2.1.1, except that a data set including acquisitions during the late winter-wheat and late spring-wheat seasons is used. In addition, the temporal plots are expanded to include LACIE and USDA/SRS acreage estimates for the total growing season. These data provide visibility into the trends, if any, that exist in the development of acreage estimates during the season.

6.2.4.2.1.3 NUMBER OF ACQUISITIONS. This task involves evaluations to determine the effects upon classification of the number of acquisitions obtained over a segment throughout the growing season.

The investigations will utilize CAMS classification and ground-truth data from acquisitions obtained over the 176 U.S. blind sites during the 1975-76 growing season.

The purpose of these evaluations is to see if the observed proportion errors ($\hat{P} - P_{GT}$) are correlated as a function of biowindow with the number of acquisitions or combinations of acquisitions over a segment during the growing season.

Proportion errors will be correlated with those segments having:

- a. One acquisition (biowindow 1, 2, 3, or 4)
- b. Two acquisitions (biowindows 1 and 2, 1 and 3, 1 and 4, or 2 and 3)
- c. Three acquisitions (biowindows 1, 2, and 3; 1, 2, and 4; 1, 3, and 4; or 2, 3, and 4)
- d. Four acquisitions

Patterns of acquisitions and the relationship of error magnitude to acquisition pattern will be examined.

6.2.4.2.1.4 AI FIELD LABELING ACCURACY. The purpose of this task is to investigate the degree of relationship that exists between observed proportion error and error in the labeling of fields by the AI.

CAMS classification data and ground-truth observations over the 176 U.S. blind sites and 27 U.S. ITS's are the basic data for these correlations.

This task is designed to establish the relationship of field labeling error to classification error and, if possible, to establish a threshold in field labeling error above which an unacceptable CAMS proportion error will probably occur.

6.2.4.2.1.5 AI DIFFERENCES. This task examines the AI classification error and determines if any pattern of differences can be noted in AI performance.

The basic data set for these investigations is CAMS classification data over the U.S. Great Plains blind sites throughout the 1975-76 growing season compared with USDA/ASCS ground-observed proportions over the same 176 blind sites.

AI performance will be evaluated by determining the relative difference $\left(\frac{\hat{P} - P_{GT}}{\hat{P}} \right)$ for each AI over each blind site. These are averaged over all the U.S. Great Plains blind sites to obtain a mean relative difference $\left(\frac{\bar{\hat{P}} - \bar{P}_{GT}}{\bar{\hat{P}}} \right)$ along with a standard deviation (σ) for this distribution. This will provide a preliminary assessment of AI error in assessing wheat proportions as well as a measure of variance noted about the mean relative difference value. Further investigations will be made, as required by an evaluation of these results.

6.2.4.2.1.6 NUMBER OF TRAINING FIELDS. This task assesses the relationship between the number of training fields selected by the AI and the CAMS proportion errors. In addition, the relationship between the number of pixels selected by the AI for training and proportion errors is examined in this task.

The basic data set for this task is the same as set out in the AI field labeling accuracy task (section 6.2.4.2.1.4), the CAMS classification data and ground-truth observations over the 176 U.S. Great Plains blind sites and 27 U.S. ITS's.

The evaluations (1) provide information as to how the number of fields selected by the AI for training relates to proportion error and (2) examine the relationship of the number of pixels or total training area to proportion error. It may be possible from these investigations to establish thresholds for numbers of fields and/or pixels required for adequate proportion estimation accuracy.

6.2.4.2.1.7 TOTAL SEGMENT WHEAT PROPORTION EFFECTS. This task evaluates the relationship between the probability of correct classification (PCC) and the proportion of wheat harvested (P_W).

The basic data set is the CAMS classification results and the ground-truth observations from test fields selected from the 27 ITS's throughout the United States.

From these data, the PCC of wheatfields is calculated along with the P_W obtained for the same fields. A regression of the PCC on P_W for these ITS's is made on a per-segment and a per-field basis.

These evaluations should provide some further understanding of the underestimation in drought areas and establish if biases in LACIE estimation could be related to the proportion of wheat that was harvested.

6.2.4.2.1.8 CAMS EVALUATION CODES. This task provides for a general investigation of the differences in the CAMS-evaluated classifications of "marginal" and "satisfactory."

The basic data set is the CAMS classification data and the ground-truth observations over the 176 U.S. blind sites and, if warranted, over the 27 U.S. ITS's.

Proportion errors for those CAMS classifications evaluated as "marginal" and "satisfactory" will be determined over representative blind-site acquisitions. Differences between these categories of CAMS evaluation codes will be calculated and evaluated.

6.2.4.2.1.9 CROP CALENDAR ERROR DETERMINATION. Major reference data utilized by AI's in their classification procedures are the nominal (mean historical) crop calendar and the ACC. Since the LACIE ACC developed by CCEA provides the latest reference information on the stage of development of wheat in an area being classified and estimated, it is necessary to determine the accuracy of this reference information. This task is designed to determine the accuracy of the ACC estimates of the wheat growth stage throughout the growing season.

The basic data set for these evaluations is the growth-stage data acquired by the USDA/ASCS personnel over the 27 U.S. ITS's. These growth-stage data are acquired utilizing the ground-truth periodic observation form presented in figure E-2 (appendix E). In addition, growth-stage information is acquired by the USDA/ASCS for each of the following CRD's:

- a. Texas (1N, 1S, 2N, 2S, 5N, 5S, 8N, and 8S)
- b. Kansas (all CRD's)
- c. North Dakota (all CRD's)
- d. Montana (1, 2, and 3)

The CRD growth-stage data are acquired by USDA/ASCS personnel using the growth-stage reporting forms presented in appendix F.

The USDA/ASCS delivers these data to the DAPTS at JSC 30 days after completion of each applicable growth stage in each CRD (stratum) or equivalent.

From these data, comparisons are made between ACC outputs (at the CRD level) and ground observations of wheat growth stages averaged to a CRD level throughout LACIE Phase II. Differences between ACC output and ground observations are recorded as days "ahead of" or "behind" the ground observations. Examinations of the variance of the ACC output over the U.S. Great Plains will be made. The relationship of this information to known episodic events of the current year, such as drought, is investigated and reported throughout Phase II AA, along with the assessment of the accuracy of the ACC.

6.2.4.2.1.10 CROP CALENDAR EFFECTS ON CLASSIFICATION AND LABELING ERRORS. A concern of AA has been to determine if the AI's use of the ACC results in more accurate wheat proportion estimates than those obtained using the nominal (mean historical) crop calendar. Since the AI's use both the nominal crop calendar and the ACC, it is difficult to assess the weight that is given to each.

The basic data set for evaluating the ACC versus the nominal crop calendar results will be the growth-stage data collected from the 27 U.S. Great Plains ITS's. In this task, scatter plots are prepared in which the abscissa is the CAMS proportion error and the ordinate is the amount, measured in days, by which the ACC is "better than" or "worse than" the nominal crop calendar. "Better than" means that the ACC is closer to the ground-truth

growth-stage data for the ITS's for the 1975-76 growing season (which are assumed to be error free). The scatter plots will be studied to disclose any correlation between CAMS proportion error and the degree to which the ACC varies from the nominal crop calendar, using ground truth as reference data.

6.2.4.2.1.11 EVALUATION OF CANADIAN INTENSIVE TEST SITE

CLASSIFICATIONS. The previous classification tasks have addressed the major thrust of Phase II AA; that is, to evaluate LACIE estimates over the U.S. Great Plains. The AA evaluations in this task are extended to investigate the accuracy of LACIE estimates using the ACC over the Canadian ITS's (appendix B, table B-2).

The data set for these investigations will be LACIE classification data and ground-truth data obtained in fall inventories and in periodic 18-day observations over the 10 Canadian ITS's. Crop growth-stage data over these ITS's are used, also, in these investigations.

The ACC error will be determined in a manner similar to that used for the U.S. Great Plains ITS's (see section 6.2.4.2.1.9). In addition, the LACIE wheat/small-grain proportion estimate ($\hat{P}$) over each ITS is compared with the ground-truth proportion (P_{GT}) over the same site. The relative difference is then calculated and examined to assess the accuracy of the LACIE acreage estimate.

In addition, the PCC is examined for the 10 ITS's by selecting 30 fields at random in each ITS and determining the number of pixels classified correctly and those classified incorrectly. From these data the PCC for the Canadian ITS's is estimated.

6.2.4.2.1.12 OTHER CLASSIFICATION EVALUATIONS.

As required throughout Phase II AA evaluations, special problem areas not previously designated as potential classification error sources

will probably be identified. As is directed by LACIE project management and the AA Team, special classification error source investigations will be conducted (provided resources are available, or as such investigations are given special priorities to be performed in lieu of some previously described classification error source evaluation tasks).

6.2.4.2.2 Sampling Accuracy

The demonstration of the LACIE project as an economically feasible system for making crop inventories dictates that only a portion of the wheat growing area be classified. As a result, a sampling subset of segments must be utilized and the results projected to the total area. The sample segments selected for classification must therefore be representative of the entire area being classified. Since potential errors can exist in the sampling process, it constitutes a major area of concern for the AA program. The following Phase II investigations are designed to examine the validity of the Phase II sampling method.

6.2.4.2.2.1 COMPARISON OF U.S. BLIND-SITE DATA WITH USDA/SRS COUNTY ESTIMATES. Since the U.S. Great Plains blind sites constitute approximately one-third of the 411 LACIE segments in the U.S. Great Plains and since they are randomly selected, they can be considered somewhat representative of this region. Evaluative information can be gained through a task designed to compare the 1976 sample-segment wheat proportions with USDA/SRS county wheat proportion estimates from the 1969 Agricultural Census.

.....
The following sampling evaluation tasks will be conducted over the U.S. Great Plains by state, by five-state winter wheat, by four-state spring and mixed wheat, and by nine-state wheat regions. This will involve estimating sampling error by regressing blind-site segment wheat proportions (P_{GT}) on the USDA/SRS

1969 historical county wheat proportions (P_{HIST}) and using the residual mean square as an estimate of the sampling error (σ_s^2).

In addition, data are available from the USDA/SRS June enumerative surveys. These survey data are used for the 1973-74 and 1974-75 crop years for selected counties, including blind sites, in order to determine better estimates of the sampling error (including the within-county and between-county error components). These tasks are completed by the Sampling Team.

6.2.4.2.2.2 WITHIN-COUNTY VARIANCE. Formulas exist from which sampling variance can be calculated. However, to use these formulas, values for within-county variance in the United States and other countries are needed. Since all other methods of evaluation of sampling variance must be based either upon past experience or upon unverifiable assumptions, values of these within-stratum or substratum variances must be estimated.

The Sampling Team estimates within-county variance through the usage of full-frame Landsat data. These data are (1) photointerpreted to identify agricultural versus nonagricultural areas in all 9- by 11-kilometer (5- by 6-nautical-mile) rectangles that make up each U.S. Great Plains county and (2) converted to wheat percentages using an algorithm developed and tested by the Sampling Team.

6.2.4.2.2.3 OTHER SAMPLING EVALUATIONS. As required throughout Phase II AA evaluations, special problem areas not previously designated as potential sampling error sources may be identified. As directed by LACIE project management and the AA Team, special sampling error source investigations will be conducted (provided resources are available, or as such investigations are given special priorities to be performed in lieu of some previously described sampling error source evaluation tasks).

6.2.4.2.3 Aggregation Accuracy

The Phase II AA acreage aggregation evaluations consist primarily of studies to check the validity of the aggregation software. These include the following.

6.2.4.2.3.1 USING USDA/SRS COUNTY ESTIMATES FOR LACIE ACQUISITION SEGMENTS. It has been shown that if USDA/SRS county wheat proportion estimates are substituted for all of the LACIE-allocated segment estimates and aggregation is made, almost no error occurs in the aggregated results when compared with regular USDA/SRS estimates. However, as indicated during Phase I, data acquisition problems, such as cloud and snow cover and hardware failure, resulted in the loss of some of the allocated segments. The following procedure will be used to determine if error is occurring in the wheat acreage estimates at the CRD, regional, and national levels because of these missing segments.

- a. Obtain USDA/SRS county estimates for those counties containing segments that have been used in the aggregation.
- b. Aggregate to the zonal, regional, and national levels using the USDA/SRS county estimates in place of the CAMS estimates.
- c. Compare the aggregated results to the USDA/SRS estimates at the zonal, regional, and national levels to determine significant differences.
- d. If differences occur, determine the causes and, if possible, make recommendations for corrections in the process. Particular attention should be given to the use of the ratio estimate for the unsampled group 3 areas.
- e. Compare the aggregated USDA/SRS county results to the aggregated CAMS results in light of the analyses performed in subparagraphs c and d.
- f. Issue a report on the effects of aggregation on the 1976 crop year data sets.

6.2.4.2.3.2 USING USDA/SRS COUNTY ESTIMATES FOR LACIE-ALLOCATED SEGMENTS. As noted in subsection 6.2.4.2.3.1, if USDA/SRS county wheat proportion estimates are substituted for all of the LACIE-allocated segment values, almost no error occurs between this aggregation versus the regular USDA/SRS estimates. When this evaluation was made in Phase I, no discrepancies were found. This task will be repeated in Phase II to ensure the accuracy of the LACIE aggregation software.

6.2.4.2.3.3 OTHER AGGREGATION EVALUATIONS. As required throughout Phase II AA evaluations, special aggregation problems not previously designated as potential aggregation error sources may be identified. As directed by LACIE project management, special aggregation accuracy problems will be investigated (provided resources are available, or as such investigations are given special priorities to be performed in lieu of some previously described aggregation error source evaluation tasks).

6.2.4.3 Yield Error Source Evaluations

The two factors in LACIE production estimation are acreage and yield. Acreage estimation error source investigations for Phase II have been described. AA evaluations of yield error sources will also be conducted during Phase II. The specific task descriptions are included in the following subsections.

6.2.4.3.1 Yield Model Estimation

The comparative AA evaluations of the LACIE yield estimates versus USDA/SRS yield estimates will be conducted throughout the Phase II growing season. These evaluations will be made each month by state at the five-state (winter-wheat) level, at the four-state

(spring-wheat) level, and at the nine-state level. Relative differences² between the LACIE and USDA/SRS estimates will be determined and evaluated throughout the season. This allows evaluation of eight winter-wheat and four spring-wheat models developed by CCEA, as well as LACIE adaptations.

6.2.4.3.2 Intensive Test Site Yield Estimation

In addition to the yield model evaluations, AA will examine LACIE yield estimates over the ITS's and compare them with yield proportions obtained from ground observations by USDA/ASCS personnel. Relative differences³ in these estimates are determined and evaluated as another assessment of yield accuracy.

6.2.4.3.3 Other Yield Error Sources

As required throughout Phase II AA evaluations, special yield problems not previously designated as potential yield error sources may be identified. As directed by LACIE project management, special yield accuracy problems will be investigated (provided resources are available, or as such investigations are given special priorities in lieu of some previously described yield error source evaluation tasks).

6.2.4.4 Development and Simulation of LACIE Performance Predictor

6.2.4.4.1 Model Development

In order to investigate the generation of error sources within LACIE subsystems and to evaluate their effects upon LACIE wheat production estimates, an LPP model will be developed. This LPP is a Monte Carlo simulation program which simulates the coverage

²
$$\frac{\text{LACIE yield} - \text{USDA/SRS yield}}{\text{LACIE yield}} \times 100.$$

³
$$\frac{\text{LACIE yield} - \text{USDA/ASCS yield}}{\text{LACIE yield}} \times 100.$$

provided by one or two satellites in Sun-synchronous orbits and predicts the acquisition of segments as a function of cloud cover, Sun angle, and biophase. It also simulates the error in wheat production estimates caused by sampling, classification (single and multipass), signature extension, crop calendar, and yield errors in the LACIE system.

The LPP computes the true values, estimated values, true variance, and LACIE-estimated variance for wheat acreage, yield, and production estimates at the stratum, zonal, regional, and national levels. It also computes true and estimated confidence levels.

During Phase II, the LPP model initially is used to study the advantage of a two-satellite system and to simulate the effect on production estimates of sampling error, classification error, and yield error. These applications are described in sections 6.2.4.4.2 through 6.2.4.4.5.

6.2.4.4.2 One- Versus Two-Satellite Acquisition Study

Every allocated sample segment in a biophase must be acquired for the LACIE to obtain optimum estimates. The acquisition rate for a given biophase is defined as the ratio of the number of segments acquired in that biophase to the number of segments allocated. The acquisition rate is often less than unity because cloud cover prevents some acquisitions. This is particularly true for bio-windows of short duration. In such cases it is expected that the acquisition rate will be greater with a two-satellite system than with a one-satellite system.

The study described below assesses the improvement in acquisition rate expected from a two-satellite system. The study consists of Monte Carlo simulations of segment acquisitions in each biophase. The acquisition rate for the one- and two-satellite systems will be studied for zone, region, and country. Cloud cover will be

simulated using appropriate cloud cover statistics. At least 10 Monte Carlo trials will be made for each satellite system. Each trial will provide an acquisition rate for each biowindow so that comparisons of acquisition rates can be made over all combinations of biophases. Specifically, the following hypothesis will be tested

$$H_0: \mu_2 \leq \mu_1 \text{ versus } H_A: \mu_2 > \mu_1$$

where μ_1 and μ_2 denote the acquisition rates for one- and two-satellite systems, respectively.

Actual acquisition rates for LACIE Phases I and II will be compared to the simulation results.

6.2.4.4.3 Sampling Error Simulation

Sampling errors are assessed by zone and region, with simulation runs assuming no classification error. The extent and scope of the simulations depend upon the availability of a proper data base; that is, estimates of the within-substratum and year-to-year substratum variances. These simulations are performed with and without simulated cloud cover so that sampling error with and without cloud cover is evaluated.

Simulations of sampling error are made at substratum, stratum, and zonal levels. This input is based on the current ongoing effort of estimating within-county variance in the U.S. Great Plains. Expected values (i.e., averages) of the acreage estimates and their corresponding variance estimates will be made by 10 Monte Carlo repetitions for each case. True acreage and the actual variance of an acreage estimate are determined by zone, region, and country. Thus, both the acreage estimates and the variance estimates are assessed for bias by comparing expected values to true values.

6.2.4.4.4 Classification Error Simulation

Simulation runs are made using the LPP to study the effect of classification errors corresponding to single-pass and multipass classifications and their combinations on acreage estimates by zones and regions. Blind-site data from Phase II will be utilized to estimate the biases and variances associated with these component errors.

An evaluation of sampling and classification error components is made by comparing estimates with their expected values for the different cases of classification error inputs along with sampling error inputs. Furthermore, multiple tests will be performed to assess the relative significance of the various error components. A minimum of 10 replications will be required for each test case.

Error model 2 analyzes the effect on acreage estimates of omission and commission errors, as well as mixed pixel errors (if good estimates of variance can be obtained from the blind-site and ITS data).

6.2.4.4.5 Yield Error Simulation

Simulation runs are made to provide an estimate of the relative effects of yield as compared with acreage estimation error and the respective ultimate effects of each on production. The importance of this part of the model will be heavily dependent on the availability of historical yield estimation results. Since yield modeling has improved considerably in recent years, this may involve estimates of how well the present model would have performed in previous years. A file of year-to-year biases and error variances for different estimation dates for each CRD will be required for a meaningful evaluation. At present, the date and availability of these data are uncertain.

6.3 ACCURACY ASSESSMENT REPORTING

During LACIE Phase II operations, AA will provide LACIE project management timely information relative to the accuracy of LACIE estimates of wheat acreage, yield, and production and with respect to specific problems that may affect these estimates. Three basic types of reporting will be utilized:

- a. Special reports and presentations to provide the most recent status data on LACIE estimates and to identify potential problems as they are disclosed.
- b. AA monthly quick-look reports, which contain rapid evaluations of the CMR's and preliminary comparisons of the LACIE estimates with USDA/SRS estimates throughout the growing season. These reports will provide LACIE project management with comparative status information relative to LACIE products throughout Phase II.
- c. Interim and final AA reports, analytical reports throughout Phase II, which include a series of interim reports in which analyses of early- and late-season winter- and spring-wheat LACIE estimates are reported. The interim reports will evolve into a final AA report presenting evaluations of LACIE estimates for the entire Phase II program.

6.3.1 SPECIAL MANAGEMENT BRIEFINGS AND PRESENTATIONS

As required to support LACIE reporting functions, special briefings will be prepared for LACIE project management relative to the current status of LACIE operational data development, particularly with respect to special problems that could affect the accuracy of final LACIE at-harvest estimates of wheat acreage, yield, and production in the U.S. Great Plains.

In addition, AA will support LACIE project management requirements to brief NASA, USDA, and NOAA upper-level management on the status

of LACIE outputs and the progress being made toward satisfying the 90-90 criterion.

These briefings will be prepared in a format that is consistent with other information being presented.

6.3.2 MONTHLY QUICK-LOOK REPORTS

The monthly AA quick-look reports are released 7 days after the CMR's and contain evaluations of the LACIE estimates presented in the CMR's. These evaluations include reviews of results and analyses of the internal consistency of the CMR and of the statistics presented in the CMR. In addition, preliminary comparisons will be made with USDA/SRS estimates for the same period in the growing season. The purpose of these quick-look reports is to provide quick estimates as to the status of LACIE estimates and to detect any early anomalies and problems that should be the subject matter of further study and analysis by LACIE AA and operations personnel.

These AA monthly quick-look reports will be released after approval by the AA manager and the branch chief of the Research, Test, and Evaluation Branch (RTEB) of NASA/JSC.

6.3.3 INTERIM AND FINAL REPORTS

The Phase II AA final report shall be developed through a series of interim reports that provide AA evaluations throughout Phase II. Each subsequent interim report includes additional AA evaluative data that have become available since the last report. In addition, subsequent interim reports will incorporate changes that result from analyses and evaluations of previous interim reports by LACIE project and technical personnel relative to AA. Figure 6-1 illustrates the developmental process of the Phase II AA reports, along with the format and basic subject matter of each. As can be noted from figure 6-1, the

critiques and comments of project technical and management personnel on each interim report will be addressed and resolved; the basic intent of these comments will be incorporated into the succeeding interim report or reports and in the final Phase II AA report.

A detailed outline to be used in the final Phase II AA report is presented in table 6-2. This outline contains the reporting elements that are considered necessary for this evaluation report.

The planned schedule for release of the LACIE interim AA reports and the final Phase II AA report is as follows:

- First interim report — May 15, 1976
- Second interim report — August 15, 1976
- Third interim report — November 15, 1976
- Final interim report — March 1, 1977
- Final Phase II AA report — 1977

The AA interim reports will require approval by the AA manager and the Chief of the RTEB of NASA/JSC prior to their release for LACIE project review and evaluation.

The final LACIE Phase II AA report will require review and approval of the following persons prior to its release for distribution:

J. L. Dragg, Chief, Applications Systems Verification
Branch, NASA/JSC

R. B. Erb, Chief, LACIE Project Office, NASA/JSC

J. D. Erickson, Chief, RTEB, NASA/JSC

F. G. Hall, LACIE project scientist, NASA/JSC

J. Hill, assistant deputy project manager for LACIE,
NOAA

R. B. MacDonald, Chief, Earth Observations Division,
NASA/JSC

J. Murphy, assistant deputy project manager for LACIE,
USDA

D. E. Pitts, manager, LACIE AA, NASA/JSC

TABLE 6-1.- YIELD MODEL DATA REQUIREMENTS SCHEDULE FOR
ACCURACY ASSESSMENT

<u>Yield model</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>
Winter wheat:						
Tex.	X	X		X	X	X
Okla.	X	X		X	X	X
Okla./Tex. Panhandle	X	X	X	X	X	
Kans.	X	X		X	X	X
Colo.		X	X	X	X	X
Nebr.			X	X	X	X
N. Dak./S. Dak.		X	X		X	X
Mont.		X	X	X	X	X
Spring wheat:						
S. Dak.		X	X		X	X
Red River Valley (Okla./Tex.)		X	X		X	X
N. Dak.		X	X	X	X	X
Mont.		X		X	X	X

NOTE: Months in which data are not required indicate that no meteorological data were input into that particular model from the previous month; therefore, yield predictions would not change.

The associated yield contributions of each coefficient, of the F-value for each variable, and of the correlation coefficient for each yield input factor are required once a year.

TABLE 6-2.— DETAILED OUTLINE OF THE PHASE II ACCURACY
ASSESSMENT REPORT

1. INTRODUCTION

1.1 OBJECTIVES OF PHASE I AND PHASE II

- To determine how well LACIE is performing in the yardstick region
- To determine causes of LACIE error and to quantify, if possible
- To make recommendations as to potential procedures or methods for reducing the error

1.2 GENERAL METHODOLOGY

A general discussion of the methods to be used by AA in:

- Data gathering
- Analysis and evaluation
- Reporting

2. SUMMARY

A general summary of significant results in the time period covered will be made in the following subsections:

2.1 EVALUATION OF PRODUCTION ESTIMATES

2.1.1 PHASE I MONTHLY PRODUCTION ESTIMATE AND REWORK

2.1.2 PHASE II MONTHLY PRODUCTION ESTIMATE

2.1.3 COMPARISONS OF PHASE I AND II PRODUCTION ESTIMATES BY MONTH

2.2 EVALUATION OF ACREAGE ESTIMATES

2.2.1 PHASE I MONTHLY ACREAGE ESTIMATE AND REWORK

2.2.2 PHASE II MONTHLY ACREAGE ESTIMATE

2.2.3 COMPARISONS OF PHASE I AND II ACREAGE ESTIMATES BY MONTH

TABLE 6-2.— Continued.

2.3 EVALUATION OF YIELD ESTIMATES

2.3.1 PHASE I MONTHLY YIELD ESTIMATE

2.3.2 PHASE II MONTHLY YIELD ESTIMATE

2.3.3 COMPARISONS OF PHASE I AND II YIELD ESTIMATES BY
MONTH

3. ACCURACY ASSESSMENT METHODOLOGY

A detailed technical discussion of the methods used and the rationale for their usage will be presented, including discussions of:

3.1 OPERATIONAL MODELS

The yield estimation model and the production, acreage, and yield aggregation models used in LACIE will be discussed briefly and referenced.

3.2 GENERAL STATISTICAL MODELS

The specific formulation of the AA statistical models that are the basis for subsequent error budget evaluations will be presented, including:

3.2.1 PRODUCTION MODEL

3.2.2 ACREAGE MODEL

3.2.2.1 Classification Error

3.2.2.2 Sampling Error

3.2.3 YIELD MODEL

3.3 ERROR BUDGET

The statistical methodology that results from the general AA statistical models described in section 3.2 will be utilized to quantify the errors in LACIE estimates and to determine if these are acceptable in order for LACIE production estimates to meet the 90-90 criterion for both Phases I and II. This section will include a discussion of how this error is distributed over the acreage and yield components, along with the specific formulation of the statistical estimates of the production error components broken down as follows.

TABLE 6-2.— Continued.

3.3.1 ACREAGE ERROR

3.3.1.1 Classification Error

3.3.1.2 Sampling Error

3.3.2 YIELD ERROR

3.4 COMPARATIVE EVALUATIONS OF LACIE ESTIMATES WITH
REFERENCE DATA (USDA/SRS and blind-site ground truth)

3.4.1 LACIE VERSUS USDA/SRS ESTIMATES

Comparative evaluations of LACIE estimates will be made with USDA/SRS estimates of production, acreage, and yield at the state, five-state, and nine-state levels within the U.S. Great Plains. Relative differences will be calculated and examined to determine any problem areas that may exist.

3.4.2 LACIE WHEAT/SMALL-GRAIN PROPORTIONS VERSUS GROUND
OBSERVATIONS OVER THE U.S. GREAT PLAINS BLIND SITES

Comparative evaluations will be made of LACIE proportion estimates of wheat/small grains with ground truth obtained from observations by USDA/ASCS personnel over the U.S. Great Plains blind sites.

3.5 LACIE PERFORMANCE PREDICTOR ERROR SOURCE SIMULATIONS
AND EVALUATIONS

The usage of the LPP model to evaluate error sources and their effects upon LACIE production estimates will be discussed, along with simulations of acquisitions of LACIE segments utilizing one or two satellites to determine potential advantages.

4. EVALUATIONS OF LACIE PRODUCTION ESTIMATES

AA evaluations utilizing the methodology described in section 3 will be reported. LACIE and USDA/SRS production estimates will be compared and examined to determine if the 90-90 criterion is being met. This will be done at the state, five-state, and nine-state levels for both Phases I and II.

TABLE 6-2.- Concluded.

5. EVALUATIONS OF LACIE ACREAGE ESTIMATES

LACIE Phase I and II acreage estimates will be evaluated through comparisons (1) between wheat proportion estimates ($\hat{P}$) and ground truth (P_{GT}) over blind sites and ITS's from the U.S. Great Plains and (2) between LACIE acreage estimates and USDA/SRS estimates by month, by state, and by region.

Error budget checks of LACIE estimates will also be reported.

Specific acreage error source investigations will also be presented.

6. EVALUATIONS OF LACIE YIELD ESTIMATES

LACIE yield estimates for Phases I and II will be compared with comparable USDA/SRS values by month at the CRD, state, and regional levels. Further investigations of the yield model will be conducted, along with specific investigations of potential error sources in LACIE yield estimates.

7. DETAILED FINDINGS OF LACIE ERROR SOURCE INVESTIGATIONS

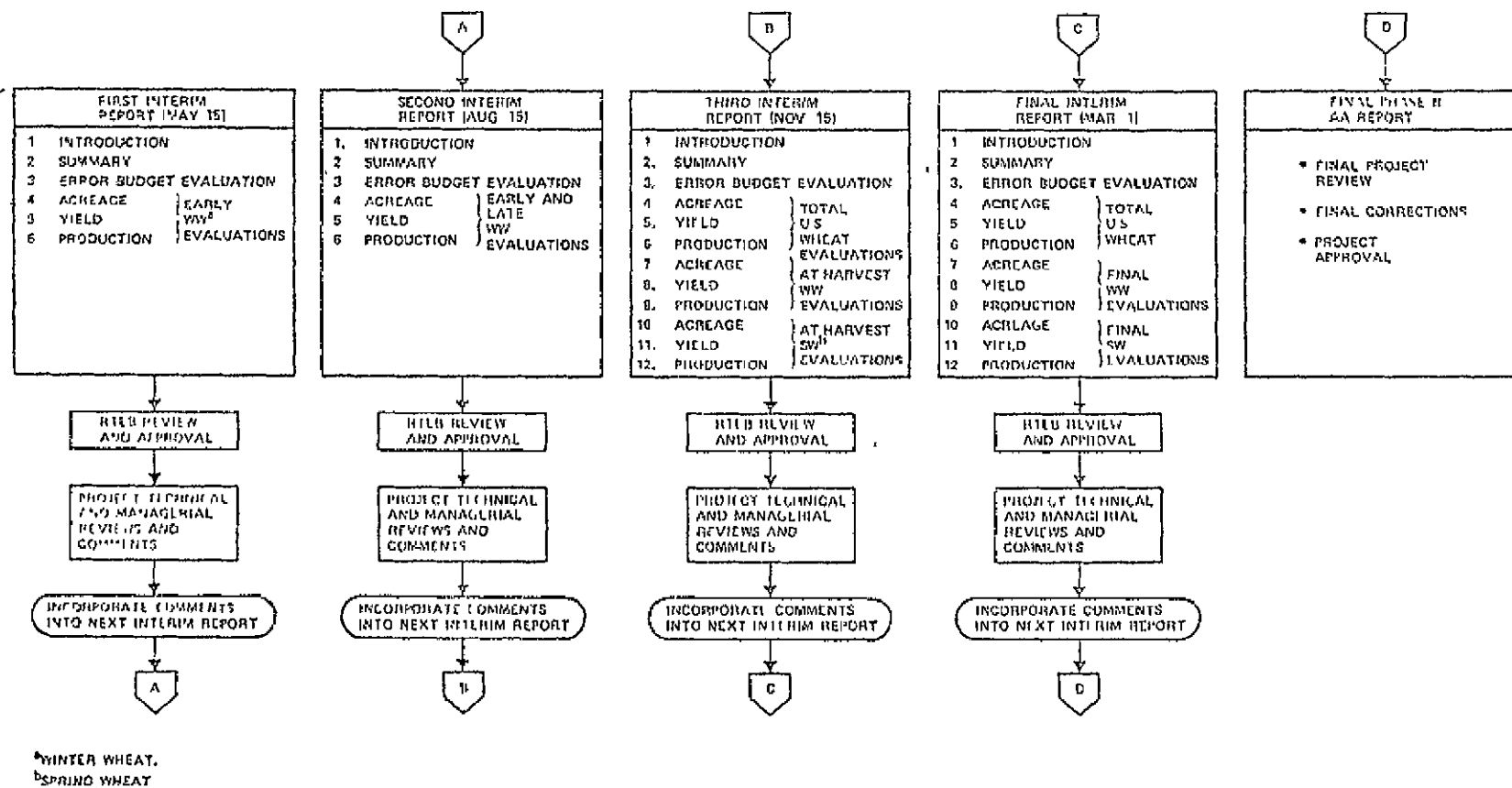


Figure 6-1.- Flow diagram for developmental processes and report formats for LACIE Phase II Accuracy Assessment Report.

APPENDIX A
ACCURACY ASSESSMENT TEAM

APPENDIX A
ACCURACY ASSESSMENT TEAM

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APPENDIX B

LACIE BLIND AND INTENSIVE TEST SITES

APPENDIX B

LACIE BLIND AND INTENSIVE TEST SITES

The LACIE ITS and blind-site selections are given in the following tables.

<u>Table</u>	<u>Sites</u>
B-1	LACIE Phase II U.S. ITS's
B-2	LACIE Phase II CANADIAN ITS's
B-3	Early-season blind-site selection from the U.S. southern Great Plains
B-4	At-harvest blind-site selection from the U.S. Great Plains

TABLE B-1.-- LACIE PHASE II U.S. INTENSIVE TEST SITES

Segment	State	County	Center coordinates		Site size		Wheat type (a)	Acquired as
			Lat., N	Long., W	N. mi.	Km		
1961	Kans.	Morton	37°16'00"	101°54'00"	5×6	9×11	WW	WW
1962	Kans.	Saline	38°41'48"	97°28'24"	3×3	5.5×5.5	WW	WW
1963	Kans.	Rice	38°17'00"	98°12'42"	3×3	5.5×5.5	WW	WW
1964	Kans.	Ellis	38°50'06"	99°13'00"	3×3	5.5×5.5	WW	WW
1988	Kans.	Finney	38°10'12"	100°43'12"	5×6	9×11	WW	WW
1965	N. Dak.	Burke	48°53'12"	102°10'00"	5×6	9×11	SW	SW
1966	N. Dak.	Williams	48°19'12"	103°24'42"	5×6	9×11	SW	SW
1967	N. Dak.	Divide	48°53'36"	103°10'54"	2×10	3.7×18.5	SW	SW
1968	Mont.	Glacier	48°37'30"	112°33'24"	2×10	3.7×18.5	S&WW	SW
1969	Mont.	Toole	48°53'00"	111°46'36"	2×10	3.7×18.5	S&WW	SW
1970	Mont.	Liberty	48°44'00"	110°51'00"	2×10	3.7×18.5	S&WW	SW
1971	Mont.	Hill	48°42'00"	109°55'00"	2×6	3.7×11	S&WW	SW
1972	Wash.	Whitman 1	46°54'36"	117°15'30"	3×3	5.5×5.5	S&WW	WW
1973	Wash.	Whitman 2	46°50'24"	117°48'18"	3×3	5.5×5.5	S&WW	WW
1974	Wash.	Whitman 3	47°08'00"	117°26'18"	3×3	5.5×5.5	S&WW	WW
1975	Idaho	Oneida	42°04'30"	112°29'30"	3×3	5.5×5.5	S&WW	WW
1976	Idaho	Franklin	42°08'00"	111°58'00"	3×3	5.5×5.5	S&WW	WW
1977	Idaho	Bannock	42°56'30"	112°25'50"	3×3	5.5×5.5	S&WW	WW
1978	Tex.	Randall	35°09'30"	102°04'24"	3×3	5.5×5.5	WW	WW
1979	Tex.	Deaf Smith	34°52'12"	102°22'18"	3×3	5.5×5.5	WW	WW
1980	Tex.	Oldham	35°15'00"	102°32'00"	3×3	5.5×5.5	WW	WW
1981	Ind.	Shelby	39°27'36"	85°47'12"	3×3	5.5×5.5	WW	WW
1982	Ind.	Madison	40°13'30"	85°37'50"	3×3	5.5×5.5	WW	WW
1983	Ind.	Boone	40°05'42"	86°33'90"	3×3	5.5×5.5	WW	WW
1987	S. Dak.	Hand 1	44°35'00"	98°58'00"	5×6	9×11	S&WW	SW
1986	S. Dak.	Hand 2	44°21'00"	98°45'06"	5×6	9×11	S&WW	SW
1987	Minn.	Polk	47°49'00"	96°41'00"	5×6	9×11	SW	SW

^aAs indicated by ground truth: S&WW = spring and winter wheat.

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TABLE B-2.— LACIE PHASE II CANADIAN INTENSIVE TEST SITES

Segment	Province	County	Center coordinates		Site size		Wheat type
			Lat., N	Long., W	S. mi.	Km	
1958	Saskatchewan	Melfort	52°48'	104°44'	2×10	3.2×16	SW
1959	British Columbia	Dawson Creek	55°48'	120°12'	2×10	3.2×16	SW
1984	Saskatchewan	Delisle	51°55'	107°28'	2×10	3.2×16	SW
1985	Saskatchewan	Swift Current	50°19'	107°53'	2×10	3.2×16	SW
1989	Alberta	Lethbridge (Raymond)	49°30'	112°48'	2×10	3.2×16	SW
1990	Manitoba	Stony Mountain	50°04'	97°21'	2×10	3.2×16	SW
1991	Manitoba	Starbuck	49°47'	97°29'	2×10	3.2×16	SW
1992	Alberta	Olds	51°54'	113°32'	2×10	3.2×16	SW
1994	Alberta	Ft. Saskatchewan	53°38'	113°07'	2×10	3.2×16	SW
1995	Manitoba	Altona	49°12'	97°38'	1×5	1.6×8	SW

TABLE B-3.— EARLY-SEASON BLIND-SITE SELECTION FROM THE
U.S. SOUTHERN GREAT PLAINS

<u>State</u>	<u>Number of group 1 segments</u>	<u>Number of group 2 segments</u>	<u>Number of code 40 segments</u>	<u>Total number of segments</u>	<u>Expected number of blind-site segments</u>	<u>Expected date of ground-truth collection</u>
Colo.	3	1	2	6	5	Late March
Kans.	10	5		15	10	Mid-March
Nebr.	4	1		5	5	Mid-March
Okla.	4	6	1	11	10	Early March
Tex.	10	3	1	14	10	Early March
Total	<u>31</u>	<u>16</u>	<u>4</u>	<u>51</u>	<u>40</u>	

TABLE B-4.— AT-HARVEST BLIND-SITE SELECTION FROM THE U.S. GREAT PLAINS

<u>State</u>	<u>Number of group 1 segments</u>	<u>Number of group 2 segments</u>	<u>Total number of segments</u>	<u>Number of segments processed in 1975</u>	<u>Expected number of blind-site segments</u>	<u>Expected date of ground-truth collection</u>
Colo.	27	5	32	24	12	July
Kans.	73	11	84	50	25	June
Minn.	8	5	13	9	5	August
Mont.	57	3	60	39	20	July
Nebr.	28	7	35	23	12	June
N. Dak.	65	0	65	42	20	August
Okla.	33	7	40	29	15	May
S. Dak.	30	3	33	23	12	July
Tex.	38	11	49	28	15	May
Total	359	52	411	267	136	

APPENDIX C
ACCURACY ASSESSMENT METHODOLOGY

APPENDIX C
ACCURACY ASSESSMENT METHODOLOGY

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SYMBOLS

A_j	true wheat acreage in the j th CRD.
B	bias.
b_i	blind-site wheat proportions from ground truth.
C_α	percentage point of the standard normal distribution at the α -level of significance.
COV	covariance.
CV	coefficient of variation.
$\hat{}$	estimate.
$E(\epsilon_{c_j})$	expected value of ϵ_{c_j} .
$E(\bar{\epsilon}_{s_j})$	expected value of ϵ_{s_j} .
$\Rightarrow$	implied statement.
n	number of samples.
N	total number of CRD's in the zone.
Pr	<u>probability</u> .
V	variance.
W	true wheat production.
$\bar{W}_0$	USDA/SRS value for wheat production.
$\hat{W}_j$	production estimate for the j th CRD.
X_i	county wheat proportions from the 1969 Agricultural Census.
Y	true wheat yield.
Y'_i	LACIE wheat proportion estimate from the i th blind site.

Y_j	true wheat yield in the j th CRD.
Z	$\frac{\hat{W} - (W + B)}{\sigma_{\hat{W}}}$
α	level of significance.
ϵ_{c_j}	error resulting from classification.
ϵ_{s_j}	error resulting from sampling.
ϵ_{w_j}	production estimation error.
ϵ_{y_j}	yield estimation error.
σ_c^2	true variance of classification error.
$\sigma_{c_j}^2$	true variance of classification error in the j th CRD.
σ_s^2	true variance of sampling error.
$\sigma_{s_j}^2$	true variance of sampling error in the j th CRD.
$\sigma_{w_j}^2$	true variance of production estimation error in the j th CRD.
$\sigma_{y_j}^2$	true variance of yield estimation error in the j th CRD.

1. INTRODUCTION

This appendix contains a description of methods to be used in (i) determining if the LACIE production estimate is meeting the 90-90 criterion and (ii) estimating various error components.

In section 3, it is shown that the 90-90 criterion will be satisfied if the CV for the production estimate at the U.S. Great Plains level, $CV(\hat{W})$, is less than a certain upper bound. This is the method used by AA to determine if the 90-90 criterion is being met. The models and assumptions used in the calculation of $CV(\hat{W})$ are described in section 2 of this appendix.

The methods of estimating error components are set out in section 4, and the effects of various error components on the production estimate are described in section 5.

The general statistical models proposed in this report express merely the functional relationship among the estimates, the true values of the estimates, and the error components of the estimates. The detailed description of the LACIE operational models and methodologies, such as acreage aggregation and yield prediction, may be obtained from the CAS and YES requirements documents (refs. 1, 2).

The assumptions made in the models are those which have been made in the LACIE Phase II operational system. The models are subject to modification to incorporate the new algorithms when they become officially available for the LACIE operational system.

2. GENERAL STATISTICAL MODELS

In this section, the statistical models for the acreage and yield estimates are presented, and these estimates are then incorporated into a model for the production estimate. The variance (V) and CV of each estimate are derived in a general form based on each formulated model and the corresponding assumptions.

2.1 ACREAGE

The statistical model for the estimate of wheat acreage is formulated as follows. Let N be the total number of CRD's in the zone under investigation and let $\hat{A}_j$ be the estimate of the true wheat acreage, A_j , in the j th CRD. Then the general statistical model for the acreage estimate in the j th CRD is given by

$$\hat{A}_j = A_j + \varepsilon_{c_j} + \varepsilon_{s_j} \quad (1)$$

for $j = 1, 2, \dots, N$, where ε_{c_j} and ε_{s_j} are the errors resulting from classification and sampling, respectively. The following assumptions are made concerning these errors.

1. ε_{c_j} is a random variable with mean zero and unknown variance $\sigma_{c_j}^2$; that is,

$$E(\varepsilon_{c_j}) = 0 \quad \text{and} \quad V(\varepsilon_{c_j}) = \sigma_{c_j}^2 \quad (2)$$

where $E(\varepsilon_{c_j})$ = expected value of ε_{c_j} .

2. ε_{c_j} and ε_{c_i} are uncorrelated, $i \neq j$, so that $\text{COV}(\varepsilon_{c_j}, \varepsilon_{c_i}) = 0$, where $\text{COV}(\varepsilon_{c_j}, \varepsilon_{c_i})$ is the covariance of ε_{c_j} and ε_{c_i} .

3. ϵ_{s_j} is also a random variable with mean zero and unknown variance $\sigma_{s_j}^2$; that is,

$$E(\epsilon_{s_j}) = 0 \quad \text{and} \quad V(\epsilon_{s_j}) = \sigma_{s_j}^2 \quad (3)$$

4. ϵ_{s_j} and ϵ_{s_i} are uncorrelated, $i \neq j$, so that $\text{COV}(\epsilon_{s_j}, \epsilon_{s_i}) = 0$.

Thus, $E(\hat{A}_j) = A_j$ ($\Rightarrow \hat{A}_j$ is an unbiased estimator of A_j),

$$V(\hat{A}_j) = \sigma_{s_j}^2 + \sigma_{c_j}^2 \quad \text{for } j = 1, 2, \dots, N \quad (4)$$

$$\text{and} \quad \text{COV}(\hat{A}_i, \hat{A}_j) = 0 \quad \text{for all } i \neq j \quad (5)$$

Consequently, the CV of the acreage estimate, $CV(\hat{A}_j)$, for the j th CRD is given by

$$\begin{aligned} CV^2(\hat{A}_j) &= \frac{V(\hat{A}_j)}{A_j^2} \\ &= \frac{\sigma_{c_j}^2}{A_j^2} + \frac{\sigma_{s_j}^2}{A_j^2} \\ &= \frac{\sigma_{c_j}^2}{\sigma_{c_j}^2 + \sigma_{s_j}^2} CV^2(\hat{A}_j) + \frac{\sigma_{s_j}^2}{\sigma_{c_j}^2 + \sigma_{s_j}^2} CV^2(\hat{A}_j) \\ &= CV^2(\hat{A}_j|c) + CV^2(\hat{A}_j|s) \end{aligned} \quad (6)$$

where

$CV(\hat{A}_j|c)$ = the CV of the acreage estimate resulting from classification error.

$CV(\hat{A}_j|s)$ = the CV of the acreage estimate resulting from sampling error.

Since the acreage estimate $\hat{A}$ for zone is

$$\hat{A} = \sum_{i=1}^N \hat{A}_j \quad (7)$$

under the assumption in equation (5), the variance of $\hat{A}$ is given by

$$\begin{aligned} V(\hat{A}) &= \sum_{i=1}^N V(\hat{A}_j) \\ &= \sigma_c^2 + \sigma_s^2 \end{aligned} \quad (8)$$

where $\sigma_c^2 = \sum_{j=1}^N \sigma_{c_j}^2$ and $\sigma_s^2 = \sum_{j=1}^N \sigma_{s_j}^2$.

Thus,

$$\begin{aligned} CV^2(\hat{A}) &= \frac{\sigma_c^2}{A^2} + \frac{\sigma_s^2}{A^2} \\ &= CV^2(\hat{A}|c) + CV^2(\hat{A}|s) \end{aligned} \quad (9)$$

2.2 YIELD

The LACIE Phase II operational yield model was formulated on a regional basis. The Phase II operational procedure implements this model at the district and zone levels to generate the yield estimates and variances of yield estimates for the district and zone, respectively.

The following statistical yield model is formulated according to the LACIE Phase II procedure. It reflects only the relationship between the estimate and the true value and the necessary assumptions in the model. Let $\hat{Y}_j$ be the yield estimate for the

true yield Y_j of the j th CRD. The model may be written as

$$\hat{Y}_j = Y_j + \epsilon_{Y_j} \quad (10)$$

where ϵ_{Y_j} is a yield error predominantly from equational error. The assumptions for the model are given as follows.

1. ϵ_j is a random variable with mean zero and unknown variance $\sigma_{Y_j}^2$; that is,

$$E(\epsilon_{Y_j}) = 0 \quad (11)$$

and

$$V(\epsilon_{Y_j}) = \sigma_{Y_j}^2 \quad (12)$$

2. ϵ_{Y_i} and ϵ_{Y_j} are uncorrelated, $i \neq j$, so that

$$\text{COV}(\epsilon_{Y_i}, \epsilon_{Y_j}) = 0 \quad (13)$$

Thus,

$$E(\hat{Y}_j) = Y_j \quad (14)$$

$$V(\hat{Y}_j) = \sigma_{Y_j}^2 \quad (15)$$

and $\hat{Y}_i$ and $\hat{Y}_j$, $i \neq j$, are uncorrelated.

2.3 PRODUCTION

Let $\hat{W}_j$ be the estimate of the true production W_j for the j th CRD. The statistical model for the production estimate is formulated as $\hat{W}_j = W_j + \epsilon_{W_j}$ for $i = 1, 2, \dots, N$. The production estimation error ϵ_{W_j} may be shown as a function of sampling, classification, and yield errors. In particular, by derivation,

$$\begin{aligned}
\hat{W}_j &= \hat{A}_j \hat{Y}_j \\
&= (A_j + \varepsilon_{c_j} + \varepsilon_{s_j})(Y_j + \varepsilon_{Y_j}) \\
&= A_j Y_j + \varepsilon_{c_j} Y_j + \varepsilon_{s_j} Y_j + A_j \varepsilon_{Y_j} + \varepsilon_{c_j} \varepsilon_{Y_j} + \varepsilon_{s_j} \varepsilon_{Y_j} \quad (16)
\end{aligned}$$

It follows that

$$\varepsilon_{W_j} = \varepsilon_{c_j} Y_j + \varepsilon_{s_j} Y_j + A_j \varepsilon_{Y_j} + (\varepsilon_{c_j} + \varepsilon_{s_j}) \varepsilon_{Y_j} \quad (17)$$

The assumption which is made for deriving the variance of production in LACIE Phase II is that

$$E[(\varepsilon_{c_j} + \varepsilon_{s_j}) \varepsilon_{Y_j}] = E(\varepsilon_{c_j} + \varepsilon_{s_j}) E(\varepsilon_{Y_j})$$

which implies that $\text{COV}(\hat{A}_j, \hat{Y}_j) = 0$ (18)

A further assumption, which is not immediately necessary and will be recalled and discussed when used, is that the production error ε_{W_j} is normally distributed with mean zero and unknown variance $\sigma_{W_j}^2$; that is,

$$\varepsilon_{W_j} \sim N(0, \sigma_{W_j}^2) \quad (19)$$

Under assumptions in equations (2), (3), (11), and (18), the following results are obtained from equation (17).

$$E(\varepsilon_{W_j}) = 0$$

That is, $E(\hat{W}_j) = W_j$ (20)

By taking the variances of both sides of equation (16), one obtains: $V(\hat{W}_j) = Y_j^2 V(\hat{A}_j) + A_j^2 V(\hat{Y}_j) + V(\hat{A}_j) V(\hat{Y}_j)$. It is noteworthy that the unbiased estimator for $V(\hat{W}_j)$, $\hat{V}(\hat{W}_j)$, is given by

$$\hat{V}(\hat{W}_j) = \hat{Y}_j^2 \hat{V}(\hat{A}_j) + \hat{A}_j^2 \hat{V}(\hat{Y}_j) - \hat{V}(\hat{A}_j) \hat{V}(\hat{Y}_j) \quad (21)$$

where $\hat{Y}_j$, $\hat{A}_j$, $\hat{V}(\hat{Y}_j)$, and $\hat{V}(\hat{A}_j)$ are the estimates of Y_j , A_j , $V(\hat{Y}_j)$, and $V(\hat{A}_j)$, respectively; and since yield variance is underestimated at the district level, the production variance obtained from equation (21) is underestimated also in the LACIE Phase II system.

The CV of production at the nine-state level is given by

$$CV(\hat{W}) = \left[\frac{\sum_{j=1}^N \hat{V}(\hat{W}_j)}{\hat{W}} \right]^{1/2}$$

$$\hat{W} = \sum_{j=1}^N \hat{W}_j \quad (22)$$

3. ERROR BUDGET

This section describes the method of determining the upper bound on the CV of production allowed by the 90-90 criterion. The 90-90 criterion can be expressed by the following probability statement.

$$\begin{aligned}
& \Pr[|\hat{W} - W| \leq 0.1W] \geq 0.90 \\
\Rightarrow & \Pr[-0.1W \leq \hat{W} - W \leq 0.1W] \geq 0.90 \\
\Rightarrow & \Pr[-0.1W - B \leq \hat{W} - (W + B) \leq 0.1W - B] \geq 0.90 \\
\Rightarrow & \Pr\left[\frac{-0.1W - B}{\sigma_{\hat{W}}} \leq \frac{\hat{W} - (W + B)}{\sigma_{\hat{W}}} \leq \frac{0.1W - B}{\sigma_{\hat{W}}}\right] \geq 0.90 \quad (23)
\end{aligned}$$

Where the bias $B = E(\hat{W}) - W$ and $\sigma_{\hat{W}} = [V(\hat{W})]^{1/2}$. Under the assumption stated in equation (19), equation (23) becomes

$$\Pr\left[\frac{\frac{-0.1W - B}{W + B}}{CV(\hat{W})} \leq Z \leq \frac{\frac{0.1W - B}{W + B}}{CV(\hat{W})}\right] \geq 0.90 \quad (24)$$

$$\Rightarrow \Pr\left[\frac{-0.1 - \frac{0.9B}{B + W}}{CV(\hat{W})} \leq Z \leq \frac{0.1 - \frac{1.1B}{B + W}}{CV(\hat{W})}\right] \geq 0.90 \quad (25)$$

where $CV(\hat{W}) = \frac{\sigma_{\hat{W}}}{E(\hat{W})}$ and $Z = \frac{\hat{W} - (W + B)}{\sigma_{\hat{W}}}$ is the relative error of the proportion estimate (relative to $\sigma_{\hat{W}}$) having standard normal distribution; that is, $Z \sim N(0,1)$.

NOTE: Since a large number of samples are utilized for the LACIE estimates, the distribution of the relative error approximates standard normal distribution. Thus, the assumption of normality for ϵ_{W_j} may be eliminated in the LACIE study.

The assumption of equation (19) is made for developing equation (25) without the consideration of sample sizes.

If $\hat{W}$ is an unbiased estimator of W , then $B = 0$ and equation (25) reduces to

$$\Pr\left[\frac{-0.1}{CV(\hat{W})} \leq Z \leq \frac{0.1}{CV(\hat{W})}\right] \geq 0.90$$

or

$$\Pr\left[|Z| \leq \frac{0.1}{CV(\hat{W})}\right] \geq 0.90 \quad (26)$$

Thus, it follows that $\frac{0.1}{CV(\hat{W})} = 1.645$, which implies that

$CV(\hat{W}) = 0.06$ is the maximum CV of the production estimate that can be tolerated for the production estimate if the 90-90 criterion is to be satisfied.

Since only one observation for $\hat{W}$ occurs at the nine-state level in LACIE Phase II, the bias B cannot be accurately estimated. However, a confidence interval might be computed to determine the upper and lower limits for B. If it is assumed that the USDA/SRS value for wheat production, W_0 , is the true value, then

$$Z = \frac{\hat{W} - (W_0 + B)}{\sigma_{\hat{W}}} \sim N(0,1)$$

and
$$\Pr \left[-C_{\alpha} \leq \frac{\hat{W} - (W_0 + B)}{\sigma_{\hat{W}}} \leq C_{\alpha} \right] = 1 - \alpha \quad (27)$$

where α is the known significance level, and C_{α} is the percentage point of the standard normal distribution at the α -level.

For the given α , $\hat{W}$, W_0 , and $\sigma_{\hat{W}}$, the confidence limits for the bias can be obtained directly from equation (27).

4. ERROR COMPONENT ESTIMATION

The formulas for estimating the various error components for the LACIE Phase II AA are presented in this section.

4.1 ACREAGE ESTIMATION ERROR COMPONENTS

In the acreage model, equation (1), the two major error components are derived from classification and sampling. If

$\{b_i\}_{i=1}^n$ represents the blind-site wheat proportions from ground

truth, and $\{X_i\}_{i=1}^n$ represents the county wheat proportions from the 1969 Agricultural Census, then the classification error σ_C^2 is estimated by..

$$\hat{\sigma}_C^2 = \frac{1}{n} \sum_{i=1}^n (Y_i' - b_i)^2 \quad (28)$$

where Y_i' is the LACIE wheat proportion estimate from the i th blind site and n is the number of samples. The sampling error σ_s^2 is estimated by regressing b_i on X_i to obtain

$$\hat{\sigma}_s^2 = \frac{\sum_{i=1}^n (\hat{b}_i - b_i)^2}{n - 2} \quad (29)$$

where $\hat{b}_i$ is the predicted value of b_i from the regression.

4.2 PRODUCTION ESTIMATION ERROR COMPONENTS

Since production is the product of acreage and yield, the acreage and the yield errors comprise the production error. The formulas for estimating these error components are given at the zone or higher level in this section.

4.2.1 ACREAGE

The acreage error (variance) for the zone or higher level was shown in equation (8), and assumptions were made and discussed in section 2.1.

4.2.2 YIELD

The yield error is more complicated and must be expressed in terms of variances for acreage and production estimates. The yield variance estimate for the zone or higher level, as given

in the CAS software requirements document (ref. 3), is as follows.

$$\hat{V}(\hat{Y}) = \frac{\hat{Y}^2}{S} \left(\frac{\sum_{i=1}^S \hat{V}(\hat{W}_i)}{\left(\sum_{i=1}^S \hat{W}_i \right)^2} + \frac{\sum_{i=1}^S \hat{V}(\hat{A}_i)}{\left(\sum_{i=1}^S \hat{A}_i \right)^2} - 2 \left\{ \frac{\sum_{i=1}^S [\hat{Y}_i \hat{V}(\hat{A}_i)]}{\left(\sum_{i=1}^S \hat{A}_i \right) \left(\sum_{i=1}^S \hat{W}_i \right)} \right\} \right)$$

where

$\hat{Y}$ = yield estimate for the area.

$\hat{W}_i$ = production estimate for the i th CRD.

$\hat{V}(\hat{W}_i)$ = estimated variance of $\hat{W}_i$.

$\hat{A}_i$ = acreage estimate for the i th CRD.

$\hat{V}(\hat{A}_i)$ = estimated variance of $\hat{A}_i$.

$\hat{Y}_i$ = yield estimate for the i th CRD.

S = number of CRD's within the area.

An approximate formula for $\hat{V}(\hat{Y})$ can be derived in the following manner.

Let the statistical model for yield estimation at the zone or higher level be

$$\hat{Y} = Y + \epsilon_Y \quad \text{with} \quad E(\epsilon_Y) = 0 \quad (30)$$

where $\hat{Y}$ is the estimate of the true yield Y at this level, then

$$\begin{aligned} V(\hat{Y}) &= V(\epsilon_Y) = E(\epsilon_Y^2) \\ &= E[(\hat{Y} - Y)^2] \\ &= E\left[\frac{\hat{A}\hat{Y} - \hat{A}Y}{\hat{A}}\right]^2 \end{aligned} \quad (31)$$

If the sample size is large, $\hat{A}$ should not differ greatly from A. The approximation consists of replacing $\hat{A}$ by A in the demoninator of equation (32). This gives

$$V(\hat{Y}) \cong \frac{1}{A^2} E[\hat{W} - \hat{A}Y]^2 \quad (32)$$

Since it was assumed $E(\hat{W}) = W$, $E(\hat{A}) = A$, and $COV(\hat{A}, \hat{Y}) = 0$, equation (32) can be written as follows.

$$\begin{aligned} V(\hat{Y}) &\cong \frac{1}{A^2} E(\hat{W}^2 + \hat{A}^2 Y^2 - 2\hat{W}\hat{A}Y) \\ &= \frac{1}{A^2} \{V(\hat{W}) + Y^2 V(\hat{A}) - 2Y[COV(\hat{W}\hat{A})]\} \end{aligned} \quad (33)$$

Since

$$\begin{aligned} COV(\hat{W}\hat{A}) &= E(\hat{W}\hat{A}) - E(\hat{W})E(\hat{A}) \\ &= E(\hat{A}^2)Y - A^2Y \\ &= [V(\hat{A}) + E^2(\hat{A})]Y - A^2Y \\ &= YV(\hat{A}) \end{aligned} \quad (34)$$

equation (33) can be written as

$$\begin{aligned} V(\hat{Y}) &\cong \frac{1}{A^2} [V(\hat{W}) - Y^2 V(\hat{A})] \\ &= \left[\frac{Y^2 V(\hat{W})}{A^2 Y^2} - \frac{V(\hat{A}) Y^2}{A^2} \right] \\ &= Y^2 \left[\frac{V(\hat{W})}{W^2} - \frac{V(\hat{A})}{A^2} \right] \end{aligned} \quad (35)$$

Consequently, this gives $CV^2(\hat{Y}) \cong CV^2(\hat{W}) - CV^2(\hat{A})$ or $CV^2(\hat{W}) \cong CV^2(\hat{Y}) + CV^2(\hat{A})$.

The estimated variance for the yield estimate, $\hat{V}(\hat{Y})$, may be obtained by replacing Y , W , A , $V(\hat{W})$, and $V(\hat{A})$ in equation (35)

with the estimators $\hat{Y}$, $\hat{W}$, $\hat{A}$, $\hat{V}(\hat{W})$, and $\hat{V}(\hat{A})$, respectively. This gives

$$\hat{V}(\hat{Y}) \approx \hat{Y}^2 \left[\frac{\hat{V}(\hat{W})}{\hat{W}^2} - \frac{\hat{V}(\hat{A})}{\hat{A}^2} \right] \quad (36)$$

Values for $\hat{V}(\hat{W})$, $\hat{W}$, $\hat{V}(\hat{A})$, and $\hat{A}$ at the zonal (state) level are given in the CMR's.

5. EFFECT OF ERRORS IN ACREAGE AND YIELD ON THE VARIANCE OF THE PRODUCTION ESTIMATE

Although the production error components are the acreage and yield errors, the production error at the zone or higher level will not be computed directly from these component errors at the same level. The effect of these errors on the production error will be determined by omitting the corresponding terms in the formulas for the variance of the production estimate given in section 2.3.

1. Production variance without acreage error: The variance is estimated as in equation (21), except that the first term is omitted; that is,

$$\hat{V}'(\hat{W}) = \sum_j \left[\hat{A}_j^2 \hat{V}(\hat{Y}_j) - \hat{V}(\hat{A}_j) \hat{V}(\hat{Y}_j) \right] \quad (37)$$

2. Production variance without yield error: It is estimated as in equation (21), except that the second term is omitted; that is,

$$\hat{V}''(\hat{W}) = \sum_j \left[\hat{Y}_j^2 \hat{V}(\hat{A}_j) - \hat{V}(\hat{A}_j) \hat{V}(\hat{Y}_j) \right] \quad (38)$$

3. Production variance without sampling error: Equation (21) is used to estimate this variance, except that

$\hat{V}(\hat{A}_j)$ is replaced by $\frac{\hat{\sigma}_c^2}{\hat{\sigma}_c^2 + \hat{\sigma}_s^2} \hat{V}(\hat{A}_j)$; that is,

$$\hat{V}_1(\hat{W}) = \sum_j \left[\frac{\hat{\sigma}_c^2}{\hat{\sigma}_c^2 + \hat{\sigma}_s^2} \hat{Y}_j^2 \hat{V}(\hat{A}_j) + \hat{A}_j^2 \hat{V}(\hat{Y}_j) - \frac{\hat{\sigma}_c^2}{\hat{\sigma}_c^2 + \hat{\sigma}_s^2} \hat{V}(\hat{A}_j) \hat{V}(\hat{Y}_j) \right] \quad (40)$$

4. Production variance without classification error: The variance is estimated as in equation (21), except that $\hat{V}(\hat{A}_j)$ is

replaced by $\frac{\hat{\sigma}_s^2}{\hat{\sigma}_c^2 + \hat{\sigma}_s^2} \hat{V}(\hat{A}_j)$; that is,

$$\hat{V}_2(\hat{W}) = \sum_j \left[\frac{\hat{\sigma}_s^2}{\hat{\sigma}_c^2 + \hat{\sigma}_s^2} \hat{Y}_j^2 \hat{V}(\hat{A}_j) + \hat{A}_j^2 \hat{V}(\hat{Y}_j) - \frac{\hat{\sigma}_s^2}{\hat{\sigma}_c^2 + \hat{\sigma}_s^2} \hat{V}(\hat{A}_j) \hat{V}(\hat{Y}_j) \right] \quad (41)$$

The CV's corresponding to the variances in equations (37) through (41) are given by

$$CV_L(\hat{W}) = \frac{[\hat{V}_L(\hat{W})]^{1/2}}{\hat{W}} \quad \text{for} \quad L = 1, 2, 3, 4 \quad (42)$$

If the reduction in the production CV obtained by omitting the acreage error is greater than that obtained by omitting the yield error [that is, if $CV_1(\hat{W}) < CV_2(\hat{W})$], this implies that the acreage estimate contributes more error to $CV(\hat{W})$ than the yield estimate. A similar comparison can be made in assessing the contributions of the classification and sampling errors to $CV(\hat{W})$.

APPENDIX D

INSTRUCTIONS TO USDA/ASCS FOR LACIE
SEGMENT INVENTORY

INSTRUCTIONS
FOR
LACIE SEGMENT INVENTORY

June 7, 1976

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- I. Introduction
- II. Data Collection Procedures
- III. JSC Contact Point
- IV. Due Dates and Mailing Procedures

I. Introduction

A. Background

The LACIE (Large Area Crop Inventory Experiment) is an interagency experiment in the use of Landsat (formerly called Earth Resources Technology Satellite) and meteorological data to identify and inventory crop production. Participating agencies include the Department of Agriculture, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration. Within the Department of Agriculture, participating agencies are the Agricultural Stabilization and Conservation Service, Economic Research Service, Foreign Agricultural Service, Agricultural Research Service, Soil Conservation Service, and Statistical Reporting Service. The overall general objectives of the LACIE are to determine utility and cost effectiveness of satellite and surface derived data sources to monitor large area crop (wheat) production and assess the impact of agricultural and meteorological conditions on production estimates. The utility of the information produced will be evaluated on the basis of its objectivity, timeliness, accuracy, and its expected value for policy and program decision making.

LACIE reports are based on data extracted from 5 x 6 mile segments that have been randomly placed throughout the

C-2

wheat producing region of the United States. In order to determine our accuracy, it is necessary that we know what is actually in our sample segment. The information requested for the segment that has been identified and forwarded to you is essential for a successful evaluation of the project. The enclosed color prints have been obtained only over the selected site in your county to support ground data collection.

B. Authority

The USDA LACIE Project Manager has requested that the Agricultural Stabilization and Conservation Service provide this function and they have accepted the assignment. You should have already gotten an authorization from your State office concerning this task. If you have not, you should contact them at once.

C. Requirements of the ASCS County Office

You are being asked to do the following:

1. Review the set of instructions.
2. Visit the segment location and identify the land uses, even if the segment falls outside your county.
3. Check over your work and return the completed inventory as soon as possible.

II. Data Collection Procedures

A. Supplies

1. Color infrared print or prints.
2. Mylar overlay.
3. Topographic map with segment location.

4. Standard crop key.
5. Crop stage development key.
6. Evaluation form.
7. Return post card and return mailing tube label.

B. In some cases, all of the segment will not be covered by the photo. Complete the survey for that portion outlined on the photo.

C. Procedures

1. You are required to identify all fields within the segment boundaries using codes as indicated on the attached crop key (see attached LACIE segment for classification).
2. Use ball point pen for all coding directly on the mylar.
3. The photos are provided as a base for field pattern and references.
 - a. All field identification should be based on actual ground conditions on the day that you visit the segment.
 - b. If there are any differences between the photo and the ground, then footnote each field that is different and explain on evaluation form.
 - c. If any fields have been harvested at the time of your visit, place a __/H after the crop code.
 - d. If any fields have not been harvested at the time of your visit, and from your observations appear to be abandoned, place a __/A after the crop code, footnote, and explain.
4. Use the evaluation form for all comments on any unusual crop condition or practice (irregular, replanting, drought, etc.).

5. If there are any crops in the segment for which there is no code, select an unused symbol and indicate its meaning on the evaluation form.
6. Assess the average wheat crop stages while completing the segment inventory and enter it on the evaluation form upon completion.

III. JSC Contact

- A. If there are any problems, contact the person listed below.
- B. Review procedures and crop key before going into the field and contact the Johnson Space Center if there are any questions.

Bobby E. Spiers, TF4
U.S. Department of Agriculture/ASCS
NASA - Johnson Space Center
Large Area Crop Inventory Experiment
Houston, TX 77058

Phone: Commercial - A/C 713-483-4623
 FTS - 525-4623

IV. Due Date and Mailing Procedures

- A. Upon receipt of data from the Johnson Space Center, complete the enclosed post card and return it to JSC.
- B. Field information should be collected within 10 days after receipt of material by your office, if at all possible.
 1. Upon completion of field survey, fill out evaluation form and return with photos.
 2. Return all material (maps and photos) in the same mailing tube you received data in, using the provided return label.
- C. Thank you for your cooperation and effort in assisting LACIE in this vital area of the experiment.

ORIGINAL PAGE IS
OF POOR QUALITY

SAMPLE SEGMENT

With Photo and Mylar
(Not to Scale)



Sample: W/A These were winter wheat fields but are currently
being plowed under due to the effects of drought.

STANDARD CROP KEY

<u>KEY</u>	<u>CROP TYPE</u>
W	Winter Wheat
SW	Spring Wheat
F	Fallow
G	Grass (not cut for hay and no fence)
H	Hay (any visible signs of hay activities)
A	Alfalfa
P	Pasture
C	Corn
SF	Safflower
SU	Sunflower
SG	Sudan grass
SR	Sorghum
SY	Soybeans
SB	Sugar beets
FX	Flax
T	Trees
R	Rye
B	Barley
X	Homestead - nonag, lakes, ponds, etc.
BN	Beans
O	Oats
(Crop)/H	Crop has been harvested
(Crop)/A	Crop has been abandoned; footnote and explain

1. If there are crops in segment for which there is no code, select an unused symbol and indicate its use on the evaluation form.
2. Use standard key for all identification.
3. Use ball point pen for all coding on mylar.

CROP STAGE KEY

<u>CROP STAGE KEY</u>	<u>STAGE</u>	<u>DESCRIPTION</u>
1.0	Planted	Seed was put in the ground.
2.0	Emerged	When one leaf per plant is visible.
3.0	Jointed	Defined as when the first node of the stem is visible.
4.0	Heading	Defined as the stage when the base of the rachis (or head) reached the same height as the ligule (or base of the shot leaf).
5.0	Soft Dough	At this stage the crop is starting to turn color. The kernels can be easily deformed when pressed between the fingers, but no "milk" or liquid should exude under such pressure.
6.0	Hard Dough	The kernels readily part from the head. The grain is firm and though it may be dented by pressure of the thumbnail, it is not easily crushed. The characteristic color of the grain has become more distinct. The leavers are brown, dry, and shrunken. Wheat in this stage may be swathed in some areas.
7.0	Harvested or Harvestable	Straw is brittle and dull yellow at this stage. The grain (if not harvested yet) is hard and breaks into fragments when crushed.

EVALUATION FORM

Segment No.: _____ County: _____ State: _____

Name: _____ Date: _____

Man-Hours Required to Complete Survey: _____

I. Based on your assessment of the development of wheat in the segment while completing the survey, what is the average wheat stage for the segment? See attached Crop Stage Key. Is the crop development this year in the segment normal, ahead, or behind as compared to previous years? Explain. Enter Crop Stage: _____

II. Comments, footnotes, and additional crop key used:

III. Comments on the effects of drought and/or winterkill:

IV. Comments and recommendations for improving these procedures for future surveys:

APPENDIX E
FORMS USED IN TAKING INVENTORIES
OF LACIE INTENSIVE TEST SITES

APPENDIX E
FORMS USED IN TAKING INVENTORIES
OF LACIE INTENSIVE TEST SITES

The following forms are used to record ground observations in the LACIE ITS's:

<u>Figure</u>	<u>Form</u>
E-1	Sample Ground Truth Inventory Form
E-2	Sample Ground Truth Periodic Observation Form
E-3	Sample form for Ground Truth Data Collection System Rainfall Measurements
E-4	Sample Yield Form

TEST SITE # 25 (SHELBY, IND.)
INVENTORY OBSERVATION

GROUND TRUTH INVENTORY FORM

DATA RECORDED BETWEEN 11/11/13
AND 11/12/13

LAND USE CROP CODES		LAND USE CROP CODES		LAND USE CROP CODES		LAND USE CROP CODES	
100 SPRING WHEAT (GEN)	211 PARAGON	304 KINSEY	410 WINSER	423 CAPLOCK	606 REDWOOD FLAX		
200 CUMULUS ATTACHED	212 HERTA	307 HAMMON	411 PCCALL	424 EAGLE SCOUT	607 CUMULUS		
201 HARLEY (GEN)	213 CONQUEST	308 MISSION	412 BRUDER	425 THAPPA	610 BUCKWHEAT		
202 LARKER	214 MISOURIAN	400 WINTER WHEAT (GEN)	413 GAINES	426 GILYENNE	611 SUNFLOWERS		
203 VALGARD	215 HELIX	401 OAK HARD NORTHERN	414 NUGATINE	427 WINDALTA	612 CRY BEANS		
204 BLANZAN	216 HILPNA	402 SCOUT	415 DRUCHAMP	428 WINDKA	613 LETTILS		
205 DICKSON	217 HGRAVIAN	403 PAPPER	416 MJO	500 GRASSES/PASTURE ETC.	614 DRY PEAS		
206 KINUS	300 LATSIGEN	404 EALLE	417 BUPT	600 OTHER CROPS (GEN)	615 SUGAR BEETS		
207 SHARRET	301 FUSSELL	405 APACHE	418 BRILGER	601 RAPESEED	616 GRAIN SORGHUM		
208 PIPELINE	302 BASIN	406 THUPH	419 AMHUR	602 RYE	617 SOYBEANS		
209 SETICS	303 KILSEY	407 SATANTA	420 TASCUSA	603 MUSTARD	618 COTTON		
210 STEPTOE	304 ROLNEY	408 CENTURK	421 STURDY	604 FLAX (GEN)	700 SUMMER FALLOW		
	305 LODI	409 BISON	422 CCNCHO	605 MURALTA FLAX	800 HIGH-AGRICULTURE		
					900 UNKNOWN CROPS		

MAP REFERENCE # OF FIELD	ACREAGE	LAND USE CROP CODE	IRRIGATED	FERTILIZED	PLANTING DATE MONTH DAY YEAR	COMMENTS
116	1.02	4 1 2	Y (N)	(Y) N	10/1/11/12	116 1.02 4-26-26
117	1.3	4 1 2	Y (N)	(Y) N	9/1/27/12	117 1.3 4-27-26
118	2.0	4 1 2	Y (N)	(Y) N	11/1/5/12	118 2.0 6-24-24
119	16.5	4 1 2	Y (N)	(Y) N	10/1/2/12	119 16.5 19-17-17
120	18.1	4 1 2	Y (N)	(Y) N	10/1/10/12	120 18.1 6-24-24
121	3.7	4 1 2	Y (N)	(Y) N	10/1/12/12	121 3.7 6-24-24
122	13.8	4 1 2	Y (N)	(Y) N	10/1/12/12	122 13.8 6-24-24
123	8.9	4 1 2	Y (N)	(Y) N	10/1/11/12	123 8.9 6-24-24
124	9.8	4 1 2	Y (N)	(Y) N	10/1/11/12	124 9.8 6-24-24
125	12.6	4 1 2	Y (N)	(Y) N	10/1/5/12	125 12.6 5-20-20
126	10.8	4 1 2	Y (N)	(Y) N	10/1/5/12	126 10.8 6-26-26
127	24.8	4 1 2	Y (N)	(Y) N	10/1/5/12	127 24.8 6-26-26
128	3.8	4 1 2	Y (N)	(Y) N	10/1/4/12	128 3.8 7-26-26
129	23.0	4 1 2	Y (N)	(Y) N	10/1/4/12	129 23.0 7-26-26
130	14.1	4 1 2	Y (N)	(Y) N	10/1/1/12	130 14.1 7-26-26
131	11.0	4 1 2	Y (N)	(Y) N	10/1/3/12	131 11.0 6-24-24
132	22.3	4 1 2	Y (N)	(Y) N	10/1/11/12	132 22.3 6-24-24
133	1.0	4 1 2	Y (N)	(Y) N	10/1/11/12	133 1.0 6-24-24
134	14.5	4 1 2	Y (N)	(Y) N	10/1/11/12	134 14.5 6-24-24
135	13.0	4 1 2	Y (N)	(Y) N	10/1/11/12	135 13.0 6-24-24
136	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	136 10.0 6-24-24
137	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	137 10.0 6-24-24
138	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	138 10.0 6-24-24
139	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	139 10.0 6-24-24
140	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	140 10.0 6-24-24
141	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	141 10.0 6-24-24
142	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	142 10.0 6-24-24
143	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	143 10.0 6-24-24
144	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	144 10.0 6-24-24
145	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	145 10.0 6-24-24
146	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	146 10.0 6-24-24
147	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	147 10.0 6-24-24
148	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	148 10.0 6-24-24
149	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	149 10.0 6-24-24
150	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	150 10.0 6-24-24
151	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	151 10.0 6-24-24
152	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	152 10.0 6-24-24
153	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	153 10.0 6-24-24
154	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	154 10.0 6-24-24
155	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	155 10.0 6-24-24
156	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	156 10.0 6-24-24
157	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	157 10.0 6-24-24
158	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	158 10.0 6-24-24
159	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	159 10.0 6-24-24
160	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	160 10.0 6-24-24
161	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	161 10.0 6-24-24
162	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	162 10.0 6-24-24
163	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	163 10.0 6-24-24
164	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	164 10.0 6-24-24
165	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	165 10.0 6-24-24
166	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	166 10.0 6-24-24
167	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	167 10.0 6-24-24
168	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	168 10.0 6-24-24
169	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	169 10.0 6-24-24
170	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	170 10.0 6-24-24
171	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	171 10.0 6-24-24
172	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	172 10.0 6-24-24
173	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	173 10.0 6-24-24
174	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	174 10.0 6-24-24
175	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	175 10.0 6-24-24
176	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	176 10.0 6-24-24
177	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	177 10.0 6-24-24
178	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	178 10.0 6-24-24
179	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	179 10.0 6-24-24
180	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	180 10.0 6-24-24
181	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	181 10.0 6-24-24
182	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	182 10.0 6-24-24
183	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	183 10.0 6-24-24
184	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	184 10.0 6-24-24
185	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	185 10.0 6-24-24
186	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	186 10.0 6-24-24
187	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	187 10.0 6-24-24
188	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	188 10.0 6-24-24
189	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	189 10.0 6-24-24
190	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	190 10.0 6-24-24
191	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	191 10.0 6-24-24
192	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	192 10.0 6-24-24
193	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	193 10.0 6-24-24
194	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	194 10.0 6-24-24
195	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	195 10.0 6-24-24
196	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	196 10.0 6-24-24
197	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	197 10.0 6-24-24
198	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	198 10.0 6-24-24
199	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	199 10.0 6-24-24
200	10.0	4 1 2	Y (N)	(Y) N	10/1/11/12	200 10.0 6-24-24

Figure E-1. Sample Ground Truth Inventory Form.

ORIGINAL PAGE 13
OF POOR QUALITY

TEST SITE # 25 (SHELBY, INDIANA) OBSERVATION 01			GROUND TRUTH PERIODIC OBSERVATION FORM					LANDSAT PASS DATE OBSERVATION DATE RAINFALL SINCE LAST OBSERVATION		MONTH, DAY 4-1-37-176 3-1-176		IN.	
LAND USE CODES	GROWTH STAGES	GROUND COVER (%)	SURFACE MOISTURE CONDITIONS	FIELD OPERATIONS	GROWTH/YIELD DETRACTANTS	STAND QUALITY							
100-SPRING WHEAT	01-NOT PLANTED	1- 0- 19	1-DRY	01-BARE GROUND	01-SALINITY	1-POOR							
200-BARLEY	02-PLANTED NO EMERGENCE	2-20- 39	2-DAMP	02-BARE DISKED/CULTIVATED	02-INSECTS	2-BELOW							
300-OATS	03-EMERGENCE	3-40- 59	3-WET	03-BARE PLOWED	03-DISEASE	3-AVERAGE							
400-WINTER WHEAT	04-TILLERING, PREBOOT, PREBUD	4-60- 79	4-STANDING WATER	04-BARE SEEDING	04-DROUGHT	4-AVERAGE							
500-GRASSES/PASTURE	05-BOOTING OR BUDDED	5-80-100		05-STANDING STUBBLE	05-MISTURC	5-AVERAGE							
600-OTHER CROPS	06-BEGINNING TO HEAD OR FLOWER			06-STUBBLE DISKED/CULTIVATED	06-WIND	6-DOES NOT							
601-RAPESEED	07-FULLY HEADED OR FLOWERING		WEED GROWTH	07-BURNED	07-HAIL	7-EXCELLENT							
602-FLAX	08-BEGINNING TO RIPEN		1-NEGLECTIBLE	08-GRAZED	08-FRUIT	8-APPLY							
607-CORN	09-RIPE MATURE		2-SLIGHT	09-WINDROWED OR SWATHED	09-BIRDS	9-WINTERKILL							
617-SOYBEANS	10-HARVESTED		3-MODERATE	12-MOWED OR COMBINED	10-POT HOLES	13-LOADING							
618-COTTON	11-DOES NOT APPLY		4-HEAVY	14-OTHER	11-UNEVEN STAND	14-LOADING							
700-SUMMER FALLOW					12-WEEDS	15-OTHER							
900-UNKNOWN CROPS													

FIELD NO.	ACREAGE	LAND USE CODE	GROWTH STAGE (CIRCLE ONE)	GROUND COVER (CIRCLE ONE)	PLANT HEIGHT (INCHES)	SURFACE MOISTURE (CIRCLE ONE)	WEED GROWTH (CIRCLE ONE)	FIELD OPERATIONS (CIRCLE ONE)	GROWTH/YIELD DETRACTANTS (CIRCLE ONE)	STAND QUALITY (CIRCLE ONE)	COMMENTS
203	11.0	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
86	31.5	607	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
52	48.2	607	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
140	24.8	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
92	19.0	617	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
16	15.0	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
64	38.3	607	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
806	24.0	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
35	16.5	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
75	27.3	607	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
909	19.8	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
69	18.7	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
234	16.0	400	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N
163	19.2	300	01 02 03 04 05 06 07 08 09 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Y N

E-3

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OF PHOTOGRAPHY

Figure E-2.- Sample Ground Truth Periodic Observation Form.

TEST SITE: 37 (FRANKLIN, IDAHO)

YIELD FORM

DATE RECORDED BETWEEN 2/19/75 AND 12/30/75
P. 1 of 2

9975

FIELD #	LAND USE CODE	HARVEST DATE MO/DAY/YR	ASCS EST	FARMER EST	SAMPLE WT. BU/ACRE	FCIC FCIC EST	STAND QUALITY RATING	COMMENT
7	100	- 9, - 6, 75	20	10	Y N	Y N	1 2 3 4 5	(Y) N
18	100	- 9, - 6, 75	100	70	Y N	Y N	1 2 3 4 5	(Y) N
19	100	- 9, - 6, 75	100	70	Y N	Y N	1 2 3 4 5	(Y) N
46	400	- 9, - 6, 75	15	12	Y N	Y N	1 2 3 4 5	(Y) N
98	100	- 9, 12, 75	90	65	Y N	Y N	1 2 3 4 5	(Y) N
181	400	- 8, 19, 75	20	18	Y N	Y N	1 2 3 4 5	(Y) N
132	413	- 9, - 6, 75	110	100	Y N	Y N	1 2 3 4 5	(Y) N
247	400	- 8, 19, 75	25	22	Y N	Y N	1 2 3 4 5	(Y) N
229	100	- 9, - 6, 75	100	105	Y N	Y N	1 2 3 4 5	(Y) N
338	100	- 9, - 6, 75		80	Y N	Y N	1 2 3 4 5	(Y) N
165	400	- 9, - 6, 75	20	18	Y N	Y N	1 2 3 4 5	(Y) N
164	400	- 9, - 6, 75		18	Y N	Y N	1 2 3 4 5	(Y) N
31	400	- 9, - 6, 75	35	28	Y N	Y N	1 2 3 4 5	(Y) N
48	400	- 9, - 6, 75	12		Y N	Y N	1 2 3 4 5	(Y) N
375	413	- 9, - 6, 75	100	97	Y N	Y N	1 2 3 4 5	(Y) N
170	100	- 9, - 6, 75		93	Y N	Y N	1 2 3 4 5	(Y) N
352	100	- 9, - 6, 75		45	Y N	Y N	1 2 3 4 5	(Y) N
368	400	- 8, 19, 75		14	Y N	Y N	1 2 3 4 5	Y N
414	100	- 9, - 6, 75		105	Y N	Y N	1 2 3 4 5	Y N
441	414	- 1, - 1, 75		105	Y N	Y N	1 2 3 4 5	Y N
		- 1, - 1, 75			Y N	Y N	1 2 3 4 5	Y N
		- 1, - 1, 75			Y N	Y N	1 2 3 4 5	Y N

Figure E-3.— Sample Yield Form.

RAINFALL MEASUREMENTS

ORIGINAL PAGE IS
OF POOR QUALITY

Figure E-4.— Sample form for Ground Truth Data Collection System Rainfall Measurements.

APPENDIX F

CROP GROWTH STAGE REPORTING FORMS

Check one:

☐ Spring Wheat

☐ Winter Wheat

Crop Year _____

GROWTH STAGE DATES FOR 10% DEVELOPMENT

MONTH AND DAY OF MONTH

ITS SEG. NO.	CRD #	PLANTING DATE ¹	EMERGENCE DATE ¹	JOINTING DATE ²	HEADING DATE ²	SOFT DOUGH DATE ³	RIPE DATE ⁴	HARVEST DATE ⁵

¹ Date at which 10% of fields in CRD were planted or emerged, respectively.

² Date at which 10% of fields in CRD had begun to joint or head, respectively.

³ Date at which 10% of fields in CRD had begun to enter soft dough stage (turning color to greenish-yellow to yellow).

⁴ Date at which 10% of fields in CRD are ripe (hard dough) stage or when they were swathed, (Indicated swathed if applicable).

⁵ Date at which 10% of fields in CRD have been harvested either as standing grain or out of swath.

Check one:

☐ Spring Wheat

☐ Winter Wheat

Crop Year _____

GROWTH STAGE DATES FOR 50% DEVELOPMENT

MONTH AND DAY OF MONTH

ITS SEG. NO.	CRD #	PLANTING DATE ¹	EMERGENCE DATE ¹	JOINTING DATE ²	HEADING DATE ²	SOFT DOUGH DATE ³	'RIPE DATE ⁴	HARVEST DATE ⁵

¹ Date at which 50% of fields in CRD were planted or emerged, respectively.

² Date at which 50% of fields in CRD had begun to joint or head, respectively.

³ Date at which 50% of fields in CRD had begun to enter soft dough stage (turning color to greenish-yellow to yellow).

⁴ Date at which 50% of fields in CRD are ripe (hard dough) stage or when they were swathed, (Indicated swathed if applicable).

⁵ Date at which 50% of fields in CRD have been harvested either as standing grain or out of swath.

Check one:

☐ Spring Wheat

☐ Winter Wheat

Crop Year' _____

GROWTH STAGE DATES FOR 90% DEVELOPMENT

MONTH AND DAY OF MONTH

ITS SEG. NO.	CRD #	PLANTING DATE ¹	EMERGENCE DATE ¹	JOINTING DATE ²	HEADING DATE ²	SOFT DOUGH DATE ³	RIPE DATE ⁴	HARVEST DATE ⁵

¹ Date at which 90% of fields in CRD were planted or emerged, respectively.

² Date at which 90% of fields in CRD had begun to joint or head, respectively.

³ Date at which 90% of fields in CRD had begun to enter soft dough stage (turning color to greenish-yellow to yellow).

⁴ Date at which 90% of fields in CRD are ripe (hard dough) stage or when they were swathed. (Indicated swathed if applicable).

⁵ Date at which 90% of fields in CRD have been harvested either as standing grain or out of swath.

APPENDIX G

REFERENCES

APPENDIX G

REFERENCES

1. Large Area Crop Inventory Experiment (LACIE) Crop Assessment Subsystem (CAS) Requirements. Vol. IV, LACIE-C00200 (rev. B), JSC-11329, July 1976.
2. Large Area Crop Inventory Experiment (LACIE) Yield Estimation Subsystem (YES) Requirements. Vol. III, LACIE-C00200 (rev. A), JSC-11340, Sept. 1976.
3. Large Area Crop Inventory Experiment Crop Assessment Subsystem Software Requirements Document. JSC-10009, Nov. 25, 1975.

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